EITIC-EU Fostering STEAM careers among schoolgirls through women role-models

Task 2.2 Methodological Handbook

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EITIC EU Project

EITIC EU is an Erasmus+ Key Action 2 (KA220-SCH) cooperation partnership project with the fundamental objective of promoting Science, Technology, Engineering, Arts, and Mathematics (STEAM) careers among girls aged 10-16 through the strategic visibility of inspiring female role models in these fields. This ambitious initiative brings together six organisations spanning five European countries —Spain, Italy, Greece, Romania, and Belgium— each contributing unique perspectives and expertise to address the persistent digital gender gap in STEAM education. The project's comprehensive approach recognises that women and non-binary individuals currently represent roughly 31% of STEAM students in higher education worldwide[1], highlighting the urgent need for targeted interventions during the critical ages of 10-16 when career interests and self-perceptions are forming.

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Context

This Methodological Handbook is designed to guide teachers, educators, and families in **creating inclusive, engaging, and empowering STEAM learning environments**. By focusing on the critical ages of **10–16**, when self-perceptions and career interests are being formed, the handbook provides evidence-based **insights**, hands-on **activities**, and **actionable guidance** to foster curiosity, experimentation, and creativity, while promoting gender equality in education.

Pedagogical approach: Learning by Doing

This handbook is grounded in **learning by doing**, a method that engages learners actively and challenges gender stereotypes that often portray girls as passive in STEAM. By placing girls at the center of the action, hands-on activities create **inclusive spaces** where they can take risks, collaborate, and lead. The **immediate feedback and visible results** of this approach increase motivation and self-confidence, while helping girls recognise their capabilities in technical and creative fields.

Experimenting → fostering curiosity through exploration and testing ideas.

Playing → encouraging creativity, collaboration, and risk-taking in a safe environment.

Creating → transforming ideas into tangible outcomes, reinforcing innovation and ownership.

Implementation

Here you'll find methodologies and activities you can replicate in class. Choose the theme that inspires you most and explore practical ways to create inclusive STEAM learning.

Interdisciplinary approach
STEAM grows stronger when subjects connect. Use cross-disciplinary activities to **spark creativity, challenge stereotypes, and show girls their place in STEAM.**

From STEM to STEAM
-See how adding the **Arts to STEM** boosts creativity and innovation. Use these activities to challenge stereotypes and make STEAM more engaging for girls.

Inter STEAM
-Discover how to connect **different ways of thinking** across disciplines. Design interdisciplinary activities that also **break down gender barriers** in STEAM.

Society and STEAM
-Link STEAM to **humanities and social issues**. Show students, especially girls, that science is deeply connected to social realities.

STEAM Beyond school
-Bring STEAM to the **real world**. Connect lessons to careers and futures so girls can see the relevance of their learning and their own potential.

Creating an inspiring community
Education is a shared effort. Here you'll find ways to engage **families, teachers, and role models** to create supportive spaces where girls feel they belong in STEAM.

Families
-Families shape girls' first ideas about their future. Explore how to **involve parents and caregivers** to strengthen support for STEAM at home.

Teachers as influence
-Teachers can open doors. Learn how **inclusive practices and mentoring** can boost girls' confidence and interest in STEAM.

Society and role models
-Girls need to see it to believe it. Use **role models and real-world stories** to make STEAM careers visible and achievable.

Resources
Explore materials designed to make STEAM more inclusive and adaptable to your needs. Go to EITIC EU's website to find open educational resources and practical tools to support your classroom activities.

Glossary of terms

Equality
Everyone receives the same opportunities and resources, without distinction.

Equity
Resources and support are adapted to the specific needs of each person, ensuring fair participation and outcomes.

Experimental Pedagogy
A teaching approach based on “learning by doing,” where students test ideas, explore through practice, and learn from direct experience instead of only theory.

Gender Inclusivity
An educational practice that ensures teaching methods, language, and activities avoid bias and actively promote equal participation of all genders.

Gender-Sensitive Pedagogy
Teaching practices that recognize and challenge gender stereotypes, ensure equal participation, and actively create space for girls’ voices and leadership in the classroom.

Inclusion
Creating learning spaces where all students, regardless of gender, background, or ability, feel welcomed, valued, and able to participate equally.

Innovative Education
Educational methods that introduce new ideas, tools, or approaches—such as technology integration or creative projects—to make learning more engaging and effective.

Intersectionality
The idea that individuals can experience overlapping and interconnected forms of discrimination or privilege (e.g., based on gender, race, class, or migration background). In education, this helps us understand that girls’ experiences in STEAM are shaped by multiple factors, not gender alone.

Learning by Doing
A hands-on pedagogical method where students learn actively through experimentation and practice, boosting confidence and motivation.

STEAM
An educational approach that integrates Science, Technology, Engineering, Arts, and Mathematics to foster creativity, problem-solving, and innovation.

STEM
A learning framework focused on Science, Technology, Engineering, and Mathematics. Adding the Arts transforms STEM into STEAM by encouraging creativity alongside technical skills.

UDL (Universal Design for Learning)
An educational approach that provides multiple ways of engagement, representation, and expression so all learners can succeed. For example, giving students choices in how they show their understanding (presentations, models, code, or drawings).

Underrepresented Voices
Groups or individuals whose perspectives are less visible or often excluded in STEAM, such as women, minorities, or students from disadvantaged backgrounds. Highlighting these voices promotes diversity and equity.

Evidence-based Framework

The development of a comprehensive methodological handbook constitutes one of the project's primary deliverables, designed to guide and inspire educators when preparing engaging activities and lessons for their classrooms, schools, and broader school communities. This methodological handbook serves dual purposes: functioning as both the theoretical foundation for the development of EITIC-EU Open Educational Resources (OER) and as a practical teaching guide, which will provide step-by-step activities, innovative methodologies, and cutting-edge tools to deliver compelling and inclusive STEAM learning experiences.

The theoretical framework, pedagogical goals, and structural design of this handbook have been meticulously informed by an exhaustive, transnational qualitative research study conducted across all partner countries. This comprehensive exploratory investigation engaged both STEAM educators and accomplished female role models working in STEAM fields, utilising semi-structured interviews, focus groups, and case study analyses to gather critical insights. The systematic investigation explored multiple dimensions of STEAM education, including career motivation factors that inspire girls and women to pursue and persist in STEAM careers, educational best practices that encourage active participation of all students, and barrier identification that analyses perceived obstacles to content delivery and career access. Additionally, the research examined cross-cultural perspectives to understand how different national educational contexts and cultural backgrounds influence STEAM engagement and career pathways for girls and young women.

Teachers across all participating countries expressed clear and consistent preferences for innovative pedagogical approaches that transcend traditional lecture-based instruction, with hands-on learning, gamified experiences, and integration of digital media, among other strategies. A particularly significant finding across all case studies was the profound influence of family members on students' career selection processes, demonstrating critical importance for long-term impact. Research from Portland State University confirms that parents with STEAM backgrounds significantly influence their children's likelihood to choose and persist in STEAM majors, creating what researchers term "STEM-specific cultural capital"[2].

Evidence-based Framework

This finding emphasises the necessity of integrating parents, guardians, and extended family networks into STEAM promotion initiatives, recognising their pivotal role in shaping young people's educational and career aspirations. For further insights on our research efforts and country-level findings, please refer to the EITIC EU Case Studies Report.

Brainstorming exercise during a transnational progress meeting (Scuola di Robotica, Genova, May 2025)

To ensure the practical application and scalability of our findings across diverse national and regional contexts, school settings, and varying levels of teacher capacity, we identified several key variables. These include capacity, availability, social involvement, institutional realities, and scope. Variables were further refined into attributes such as preparation time, execution time, stakeholder reach, available resources, and interdisciplinarity, respectively.

These factors were derived from a thematic analysis of the EITIC EU Case Studies Report and a comparative, multi-stakeholder, and multidimensional review of data collected from both teachers and STEAM role models. Furthermore, the interdependencies among these attributes were mapped to develop indicators reflecting different levels of feasibility, reach, and impact. Each attribute was categorised into three levels —low, medium, and high— as outlined below:

Evidence-based Framework

Variable	Attribute	Low	Medium	High
Capacity	Preparation Time	≤1 h of teacher prep; ready-made worksheets	2–4 h of prep; adaptation of open resources	≥1 day of collaborative design; bespoke materials
Availability	Execution Time	Single lesson (40–60 min) burst activity	Short project across 2–3 lessons or club meetings	Multi-week project, integrated in timetable or extra-curricular programme
Social Involvement	Reach	Core class only	Multiple classes or cross-grade cohorts	Whole-school events plus family/community partners
Institutional Realities	Resources	No-cost/low-cost items (printouts, recyclables, free apps)	Modest budget for consumables, sensors, software licences	Dedicated STEAM labs, robotics kits, expert mentors, travel funds
Scope	Interdisciplinarity	Single-subject module (e.g., math focus)	Cross-STEAM integration (S+T or E+A combinations)	Transdisciplinary links to humanities, social issues, entrepreneurship

Evidence-based Framework

Using the Framework in Practice:

- Self-audit: Teachers rate their current context on each attribute to obtain a profile (e.g., Low Prep / Medium Resources / High Reach).
- Activity matching: Teachers can cross-reference the profile with annotated OER tags so only activities of compatible demand are shortlisted.

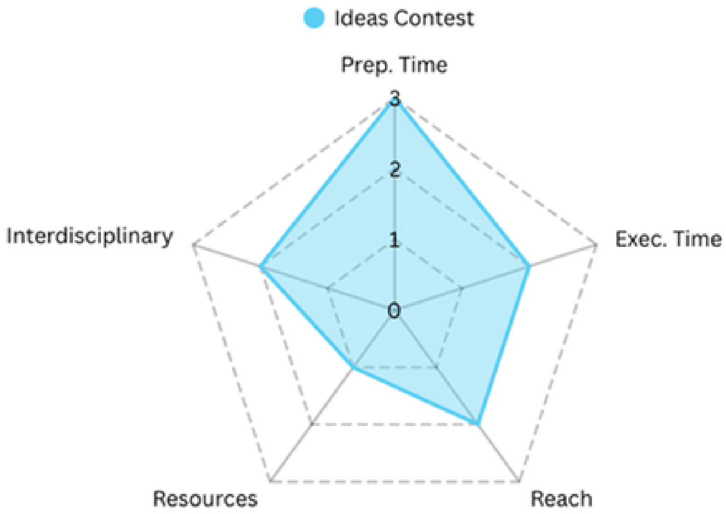
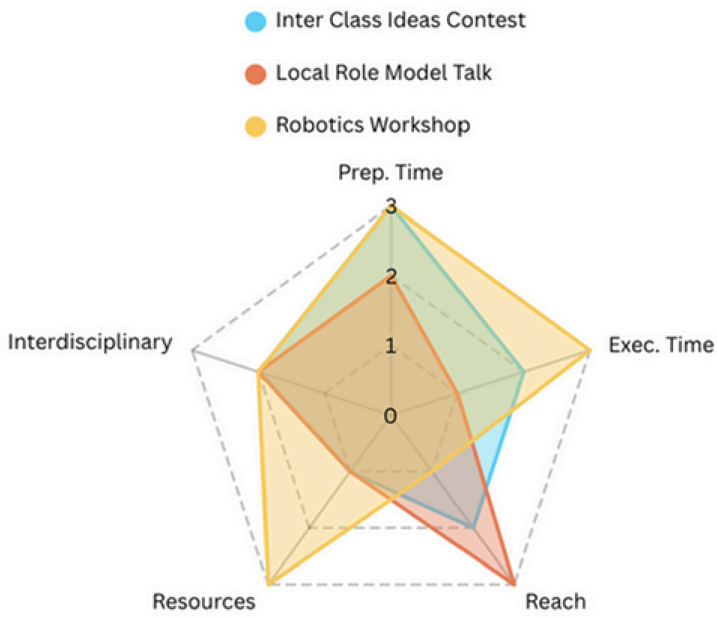


Figure 1. Example OER activities tag

- Scaffolding for growth: The three-level gradation encourages progressive scaling: begin with low-prep pilots, then advance to medium- or high-intensity versions as confidence and support grow within a wider approach. This approach also helps to visualise how to tackle different areas with a combination of specific activities.



- Equity lens: By foregrounding Social Reach and Resources, the framework helps teachers anticipate inclusivity gaps, such as access for girls with limited home technology, and prompts early family engagement strategies.

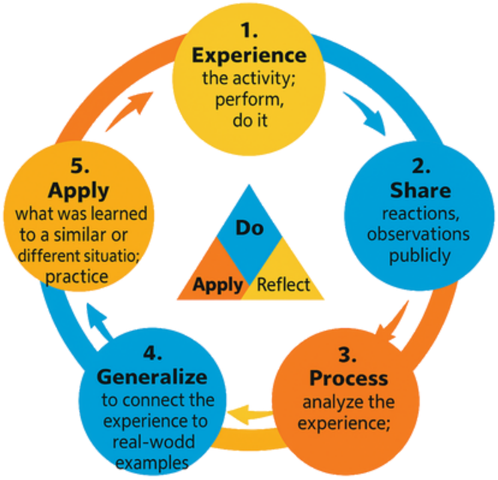
Goals

Drawing on our findings and the breadth of the proposed framework, we have set the following goals for our methodological handbook:

- **Goal 1**: Provide clear, hands-on instructions for teachers —main goal.
- **Goal 2**: Promote an interdisciplinary approach that integrates art, connects learning with real-world issues and social causes, and enhances students' critical thinking skills.
- **Goal 3**: Creating an inspiring community with role models. Engage families and give them tools to encourage and support their kids' interest in STEAM.

Learning by doing is a pedagogical method based on the idea that we can learn something better and faster if we put it into practice.

This foundational principle represents more than a teaching technique —it embodies a transformative educational philosophy that challenges traditional passive learning models. Dewey's approach to education was grounded in pragmatism and democratic ideals. He believed that education should not be preparation for life, but "life itself". This philosophy becomes particularly powerful when applied to STEAM education for girls, as it directly addresses many of the barriers that traditionally discourage female participation in these fields. Dewey's Laboratory School at the University of Chicago demonstrated that when students —regardless of gender— engage in meaningful, hands-on activities connected to real-world challenges, they develop both intellectual capabilities and social consciousness.By giving the learner an active role, they know their responsibility in the process and their evolution. In the course of learning, the learner creates valuable content and increases their motivation.



Source: https://www.pedagogy4change.org/john-dewey/

"We learn by doing. Our world is an ever-changing, practical world that we can only know through action."

John Dewey

For girls in STEAM, this active engagement is particularly crucial because it increases engagement and ownership of the learning process, countering stereotypes that girls are passive learners. The hands-on nature of experiential learning enhances motivation through activities that provide immediate feedback and visible results, while simultaneously promotes responsibility and self-awareness that helps girls recognise their capabilities in technical fields.

Autonomous Learning and Critical Thinking

The learners develop their critical thinking in the face of a problem and transfer their knowledge effectively based on their own experience. This advantage is especially important for girls because this strategy develops critical thinking through problem-solving in contexts that feel relevant and meaningful. The experiential approach enables knowledge transfer through personal experience, making abstract STEAM concepts concrete and applicable, while constructing meaningful learning through reflection —a process that research shows particularly benefits female learners.

Skills Development & Teamwork

This practice promotes the development of soft skills such as adaptability, creativity, teamwork, and decision-making, among others, highly valued by employers today. For girls entering STEAM fields, these skills are essential because they develop adaptability and creativity through open-ended, exploratory activities. The learning by doing approach enhances teamwork and collaboration skills that are increasingly valued in STEAM careers, while improving decision-making and leadership abilities through authentic project experiences that provide real-world context and application.

Working in teams is beneficial for problem-solving, even after initial failures, because collective thinking generates more ideas and solutions, diversifies perspectives, identifies risks, and fosters a greater sense of commitment and shared responsibility. By analysing failures as learning opportunities, teams can build on what worked, gain a deeper understanding, improve skills, and maintain motivation to ultimately achieve better, more innovative outcomes than individuals could alone. [3]

Gender-Inclusive Benefits

Learning by doing in STEAM education provides additional advantages specifically relevant to promoting girls' participation. This methodology breaks down gender stereotypes by demonstrating that girls can excel in hands-on technical activities while building confidence through practical achievements that provide concrete evidence of capability. This approach provides opportunities for diverse participation styles that accommodate different learning preferences, ensuring that all students can engage meaningfully with STEAM content regardless of their individual learning style or background.

Real-World Connection

The experiential approach creates powerful connections between theory and practice by connecting theoretical knowledge to practical applications, making STEAM subjects more accessible and relevant to students' daily lives. This methodology addresses community-focused problems that particularly appeal to girls' interests in social impact, while demonstrating the relevance of STEAM in everyday life and helping girls envision future career possibilities in these critical fields.

Evidence supports this approach. A university impact study (KU Leuven & Greenlight for Girls, 2018[4]) shows that girls need three elements—confidence, community, and connections—to increase their engagement in STEM subjects and careers. Experiential, real-world learning directly contributes to these needs, as it builds self-belief, fosters collaboration, and connects knowledge to meaningful futures.

The same study also highlights that girls are more motivated when STEM is seen as offering both communal goals (working with, helping, and caring for others and the world) and agentic goals (achieving, being independent, and gaining recognition). This reinforces the importance of designing STEAM activities that allow girls to feel collaborative and ambitious at the same time.
To structure these “learning by doing” methodologies, we have identified three main categories of activities to kickstart and organise different hands-on exercises: experimenting, playing, and creating.

Experimenting

Drawing on recent academic research, experimenting as a pedagogical approach has gained substantial empirical validation as a cornerstone of effective learning by doing methodologies. A comprehensive 2024 rapid evidence assessment conducted by researchers at UCL's Institute of Education, analysing 44 peer-reviewed studies from the last decade, demonstrates that experiential learning approaches —including hands-on experimentation— significantly enhance students' academic achievement, particularly in science and mathematics subjects[5]. The research reveals that experimental pedagogy develops critical general skills, including problem-solving, critical thinking, memory, and vocabulary development, with these competencies serving as foundational elements that support learning across multiple curriculum areas.

Complementing this evidence, a landmark analysis of 10 field experiments across four Latin American countries provides robust causal evidence that inquiry and problem-based pedagogy (IPP) —which centres on collaborative problem-solving through real-world experimentation— increases mathematics test scores by 0.18 standard deviations and science test scores by 0.16 standard deviations after just seven months of implementation[6].

This approach transforms students from passive recipients of information into active investigators who *"learn by collaboratively solving real-life authentic problems, developing explanations, and communicating ideas"* through structured experimental activities.

Activity 1: Design a Dream City Block

Target group: Students aged 12-17

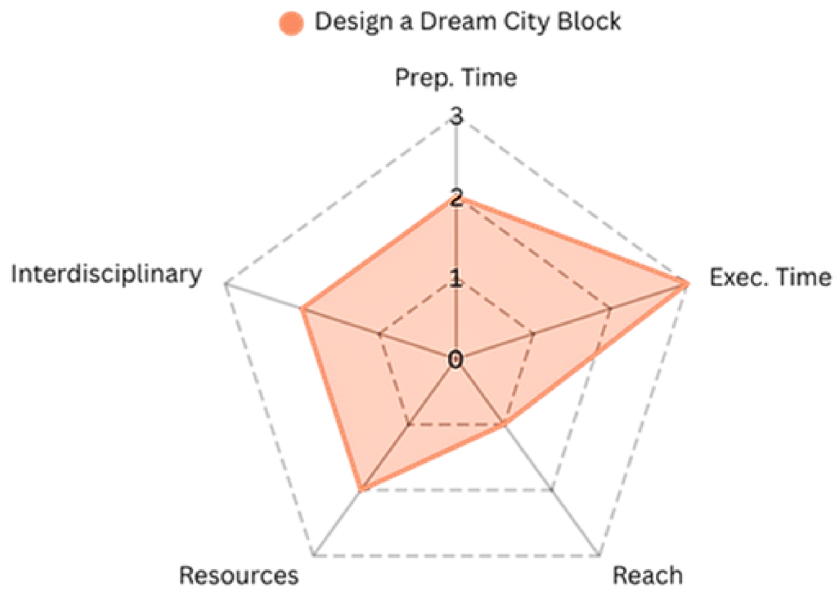
Objective: Students work in teams to design and build a section of a sustainable, accessible, and creative city using LEGO bricks.
-How can we design a better city for everyone using creativity, technology, and teamwork?

Description:

1. **Introduce the challenge**: Present a scenario: "Your team is in charge of building a new city block. It must include places to live, learn, play, and move around —while being safe, inclusive, and eco-friendly."
2. **Plan and sketch**: Teams brainstorm and sketch their ideas. Encourage them to think about:
   - Who lives there?
   - How do people move around?
   - Where does energy come from?
3. **Build a model**
   a. Build with LEGO: Using basic LEGO bricks, each team constructs their city block based on their plan. Creativity is encouraged —reuse pieces, invent new features, name streets or parks.
   b. Build with 3D models: Using digital resources such as [SketchUp](), each team builds their block based on their plan. allowing everyone to make small adjustments that the group can then review to establish the final version.
   c. Present and reflect: Teams present their builds to the class, explaining their design choices. Peers give positive feedback and ask questions.

This activity brings STEAM and PBL to life by turning students into city designers —solving real-world problems through imagination, construction, and teamwork, just like real engineers and creators do.

***PBL (Project-Based Learning)** is a method where students gain knowledge and skills by working over an extended period of time to investigate and respond to real-world questions, problems, or challenges.PBL encourages active exploration, collaboration, critical thinking, and creativity.*



Experimenting

Recent research specifically addressing gender inclusivity in experimental learning environments reveals that Gender Responsive Collaborative Learning Strategy (GR-CLS), when implemented in both virtual (e.g Activity 1, 3D models) and hands-on laboratory (e.g. Activity 1, Build with LEGO) settings, significantly improves both male and female students' achievement and attitudes toward science, with particular benefits for female students who often experience marginalisation in traditional competitive laboratory environments[7]. The 2020 study found that experimental approaches incorporating gender-responsive elements create more equitable learning opportunities by providing "maximum opportunities for interaction, discussion and cooperation when performing a task to solve a problem or to create a product".

Contemporary research also validates the technological enhancement of experimental pedagogy, with a 2020 study showing that discovery learning models integrated with scientific approaches effectively develop 21st-century skills, including creative and critical thinking[8]. The evidence consistently demonstrates that experimental learning approaches are "especially beneficial for low-achieving students," suggesting that hands-on experimentation serves as a powerful tool for promoting educational equity. Furthermore, systematic reviews of STEAM education implementation reveal that experimental pedagogies positively impact not only academic performance but also students' motivation, engagement, and sense of agency —factors that research identifies as crucial for sustained learning and career interest in STEM fields.

Experimenting

Experimenting creates a safe-to-fail environment that fundamentally transforms failure from a source of anxiety into an integral component of the learning process, thereby relieving students from the debilitating pressure of immediate success. Research by Manu Kapur on Productive Failure demonstrates that when students are deliberately allowed to struggle with complex problems before receiving instruction, they develop deeper conceptual understanding and transfer abilities compared to traditional direct instruction methods, even when their initial attempts result in failure[9]. This approach works because experimenting establishes what educational researchers call "temporary and controllable failure" experiences that, when followed by appropriate feedback and reflection, become powerful learning opportunities rather than indicators of inadequacy[10]. Janet Metcalfe's comprehensive research on learning from errors reveals that errorful learning followed by corrective feedback is beneficial to learning, particularly when students can engage in low-stakes experimental situations where the consequences of failure are minimal[11].

The pedagogical value lies in creating classroom environments where students understand that "failure is the most important ingredient in science" and that experimental approaches normalise struggle as part of the scientific process, enabling learners to develop both cognitive resilience and genuine understanding through hands-on exploration[12]. Contemporary studies further demonstrate that when educators deliberately design low-stakes failure experiences within experimental learning contexts, students report increased confidence, enhanced problem-solving abilities, and reduced anxiety about making mistakes, as the focus shifts from performance outcomes to learning processes[13]. This experimental pedagogy effectively removes the traditional pressure to achieve immediate success by reframing failure as valuable data that informs subsequent learning, creating what researchers term a "failure-positive mindset" essential for deep engagement with complex subject matter.

Activity 2:
"What's in the Water?"
Exploring Micro-ecosystems

Target group: Students aged 10–14
Objective: To explore the microscopic life found in natural water sources, encouraging inquiry,
data collection, and collaborative analysis.
Description:
1. Introduce the mystery: Show students a closed jar of pond water and ask:
- Do you think this water is "alive"?
- What might we find inside it?

List predictions on the board.

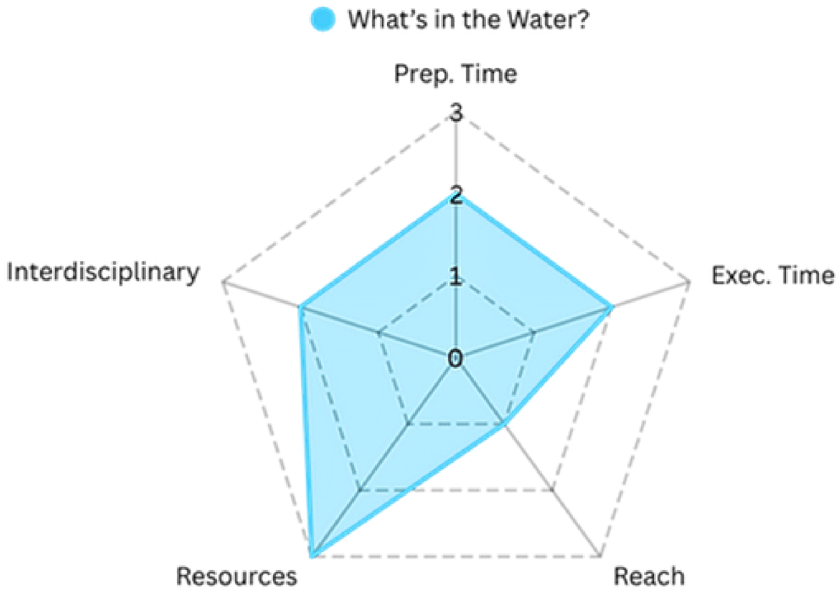
2. Explore and observe: In pairs or small groups, students:
- Use hand lenses or microscopes to observe samples of water from different sources (e.g., pond, tap, rainwater).
- Record observations by drawing, taking photos, or writing down what they see.

Optional: Use simple digital microscopes connected to a tablet to project findings in real time.

3. Compare and ask: Back in groups, students compare their results:
- Which sample had more visible life?
- Were the organisms moving? How did they behave?
- What do they think these organisms need to survive?

Encourage them to come up with questions or small experiments to try later (e.g., What happens if we leave the sample in the sun for a day? What happens if we put a tablespoon of salt in a glass with this water? If you will observe the probe in time, will there be differences? Why?).

4. Reflect and connect: End with a reflection:
- What surprised you the most?
- How do scientists explore invisible worlds?
- What skills did you use today that connect to science, tech, or art?



Playing

Recent research demonstrates that playful pedagogies are situated within experiential learning, integrating play, humour, spontaneity, and levity to create engaging educational experiences that emphasise hands-on, applied learning processes[14]. Contemporary studies reveal that learning through play happens when activities are experienced as joyful, meaningful, actively engaging, iterative, and socially interactive —characteristics that directly parallel Dewey's emphasis on learning through direct experience and reflection. The 2019 LEGO Foundation study of integrated pedagogies confirms that approaches such as experiential learning, inquiry-based learning, and problem-based learning can create learning experiences that are fundamentally playful, demonstrating that play-based methodologies are not separate from but rather integral to effective learning by doing approaches[15].

From a neurological and cognitive development perspective, recent academic literature provides compelling evidence for play's critical role in facilitating the deep learning that characterises effective experiential education. The National Institute for Play's 2024 research confirms that playful experiences form and establish neural pathways in mammalian brains, creating "PLAY circuits" that confer benefits, including stress management, social navigation, and attitudes that promote curiosity and encourage learning[16].

Playing

Furthermore, contemporary neuroscience research reveals that play-based learning approaches improve learning outcomes by approximately four additional months compared to traditional methods, while simultaneously developing executive function, problem-solving abilities, and critical thinking skills essential for experiential learning[17].

The practical implementation of play within learning by doing pedagogies has demonstrated measurable educational effectiveness across diverse contexts and age groups. A 2024 systematic review of playful learning in primary education found that effective implementation of playful pedagogic activities requires planning for desired learning outcomes while nurturing holistic child development[18]. Recent studies confirm that playful learning experiences appear to be a particularly effective mechanism for developing broad, dynamic, and interconnected skills, including the *"6 C's"* of communication, collaboration, creativity, critical thinking, confidence, and content knowledge. The 2024 Playful Learning research extension from Denmark, involving six university colleges, demonstrates that playful pedagogies create transformative, high-quality learning experiences that support both academic achievement and social-emotional development[19]. This evidence base supports the conclusion that play is not merely compatible with learning by doing pedagogies but serves as a fundamental catalyst that enhances the effectiveness, engagement, and long-term retention of experiential learning approaches.

Activity 3: The STEAM Quest

Target group: Whole grade level (students aged 10–14)

Objective: To foster experiential and playful learning through a large-scale, collaborative and competitive event that blends creativity, problem-solving, and hands-on challenges across STEAM subjects.

Description:
Design the challenge circuit: Prepare 5–7 playful stations, each inspired by a different STEAM area. Example challenges:

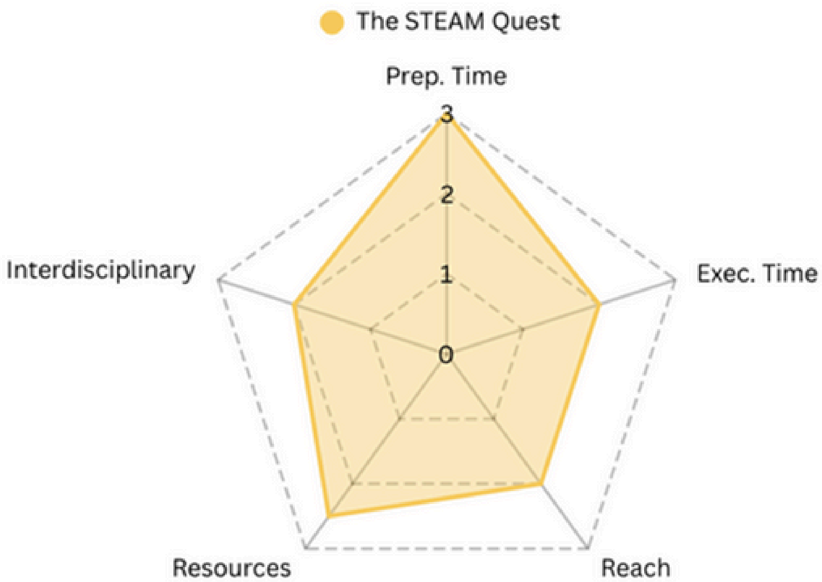
- **Science**: “Volcano Lab Mishap” → Use safe materials to trigger a chain reaction
- **Technology**: “Code the Bot” → Program a simple robot or follow an algorithmic logic path
- **Engineering**: “Bridge Builders” → Build the longest freestanding bridge using only straws and tape
- **Art**: “Pixel Puzzle” → Recreate an image in teams using colored squares, communicating only nonverbally
- **Math**: “Treasure Map Logic” → Solve spatial reasoning problems to find a secret location on a map

Divide the entire year group into mixed teams (4–6 students per team), combining students from different classes. Teams choose a name, create a simple team flag or logo, and receive a STEAM Quest Passport to track their progress.

Each station scores points based on teamwork, creativity, and solution (not just success), ensuring all learners are celebrated.

Teams rotate through the stations in timed blocks. At each one, they complete the challenge, get feedback from facilitators (teachers or older students), and collect stamps or points in their passport.

Encourage humour, role-play, storytelling, or light surprises to increase engagement —e.g., teachers in character, bonus tokens for collaboration, or playful plot twists between stations.



Creating

Maker education, rooted in Seymour Papert's constructionist theory, operates on the principle that "learning is most effective when part of an activity the learner experiences as constructing a meaningful product"[20]. Contemporary studies reveal that this pedagogical approach involves students in hands-on creation of physical and digital artefacts, from programming computer applications to building mechanical devices, fostering what researchers term "maker mindsets" characterised by creativity, persistence, and collaborative problem-solving[21]. The 2024 systematic review of maker education highlights that "the core of maker education is learning from creation," where students develop both technical competencies and critical thinking skills through the iterative process of designing, prototyping, testing, and refining their creations. This approach fundamentally shifts educational practice from instructional transmission models to constructionist environments where learners actively build knowledge through the physical act of making.

The empirical evidence supporting creating and making pedagogies demonstrates significant positive impacts on student learning outcomes across multiple dimensions. A comprehensive 2024 scoping review of maker projects in elementary schools found that students engaged in making activities showed measurable improvements in "affective, social, disciplinary, and metacognitive dimensions," with particular enhancement in creativity, critical thinking, and collaborative skills[22]. Research conducted through design-based learning models reveals that students who construct tangible artefacts achieve better knowledge integration and transfer, with studies showing improved web design skills and enhanced problem-solving capabilities among participants. The 2023 investigation of hands-on instructional approaches in cultural and creative arts education demonstrated that students retain 75% of what they learn when they practice and 90% when they teach or use knowledge immediately, significantly outperforming traditional lecture-based methods[23]. Furthermore, recent studies on tangible learning environments show that when students manipulate physical objects embedded with digital technologies, they develop deeper conceptual understanding through what researchers describe as "collaborative hands-on interaction" that promotes exploratory learning and balanced participation[24].

Despite the demonstrated benefits, implementing, creating, and making pedagogies presents significant challenges that require careful consideration of pedagogical design, resource allocation, and teacher preparation. Recent research indicates that successful maker education programs require structured frameworks that balance "tinkering to discover" with "making to learn" approaches, where educators must skillfully scaffold student exploration while maintaining focus on specific learning objectives[25]. Maker education and teacher training reveal gaps in professional development, with many educators lacking confidence in integrating making technologies into their curricula, particularly in primary and secondary settings where resource constraints and assessment pressures create implementation barriers. Effective making pedagogies demand careful attention to "project difficulty, structure, and authenticity" as key factors influencing student engagement and learning outcomes[26].

Moving forward, research suggests that the field requires continued development of assessment methodologies that capture the complex, multifaceted learning that occurs through making, while also addressing equity concerns to ensure that hands-on creation opportunities are accessible to all students regardless of socioeconomic background or institutional resources.

Activity 4: Geometry Hunt: Shapes in the Wild

Target group: Students aged 10–16

Objective: To help students apply their knowledge of geometric shapes by identifying and documenting them in real-life contexts , and then representing their findings creatively.

Rooted in maker education principles, this activity transforms geometry from an abstract topic into a concrete, creative exploration. By looking for shapes in nature and architecture, students actively connect classroom knowledge with the world around them. The final creation phase gives learners ownership of their understanding, encouraging artistic expression, critical thinking, and iterative design—key components of constructionist learning.

Description:

1. Launch the challenge

Introduce or review key geometric concepts: types of triangles, regular polygons, angles, symmetry, etc. Then present the challenge:

"Your mission is to go out into the world and hunt for geometry. Use your phone, camera or tablet to take photos of real shapes you can identify—on buildings, in trees, in street signs, on clothes, in shadows… anywhere!"

Remind them they're not just collecting photos—they're collecting evidence of math in the real world.

2. The exploration phase *(homework)***:**

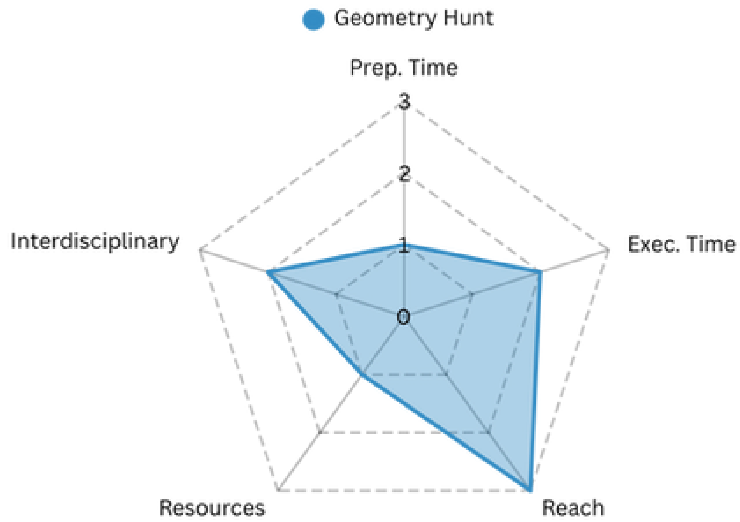
Students take a "geometry walk" where they must find and photograph:

- At least 3 triangles (equilateral, isosceles, scalene)
- At least 2 regular polygons (e.g. square, hexagon)
- 1 example of symmetry
- Any "bonus" geometry they spot (3D shapes, irregular forms, etc.)

3. Creation and making *(class sessions or homework)***:**

Students use their images to create a product that shows their discoveries. They choose how to represent what they found, e.g:

- A poster with photos and annotations
- A digital collage or interactive slide deck
- A handmade model of a building or natural shape inspired by what they observed
- A mini photo-book with geometric reflections
- A creative sculpture or art piece built from recycled materials using the same shapes



Interdisciplinary approach

From STEM to STEAM

Integrating the arts into STEM education is essential for fostering true innovation. While STEM disciplines provide critical technical skills, they often lack emphasis on creativity, empathy, and human-centered thinking. Without the arts, we risk developing a society proficient in technical skills yet deficient in the creative and emotional insights necessary for groundbreaking innovation.

Supporting this view, a study from Michigan State University[27] found that STEM graduates with substantial exposure to the arts were significantly more likely to own businesses or file patents, underscoring the arts' role in enhancing inventive capabilities. Therefore, incorporating the arts into STEM — transforming it into STEAM— ensures a more holistic education that nurtures both analytical and creative talents, essential for addressing complex, real-world challenges.

Integrating creativity into education is essential for developing a more complete understanding of intelligence. According to Sternberg’s[28] triarchic theory, intelligence includes not only analytical and practical components but also a creative dimension, which involves the ability to generate novel and effective solutions to problems. Similarly, Gardner’s[29] theory of multiple intelligences emphasizes that each type of intelligence —be it linguistic, musical, interpersonal, or logical-mathematical— has its own form of creativity. This suggests that fostering creativity in students is not optional but a vital part of supporting their full intellectual potential. Creativity, then, is not merely a trait but a habit and attitude that can be cultivated through practice and reinforced through education.

From STEM to STEAM

This perspective strongly supports the inclusion of the arts in STEM fields, transforming STEM into STEAM. When creativity is recognized as a core component of intelligence, the arts become an essential element in fostering innovation, problem-solving, and adaptability —skills critical in science, technology, engineering, and math. The arts promote divergent thinking, emotional intelligence, and multiple forms of expression, helping students connect concepts across disciplines. As both Sternberg and Gardner argue, developing creativity enhances learning outcomes and leads to more holistic, engaged thinkers who are better prepared to tackle complex real-world challenges.

Creativity & Science

As a way to bring creativity more intentionally into STEM learning, we suggest drawing inspiration from Bill Lucas's[30] five-dimensional model of creativity, originally developed for schools. His framework identifies five core habits — being inquisitive, imaginative, persistent, collaborative, and disciplined— which we propose adapting into a STEAM-specific framework. These dimensions offer concrete pathways for educators to embed creative thinking into interdisciplinary learning:

1. Explorative Thinking (from "Inquisitive")

The ability to ask meaningful questions, investigate complex phenomena, and challenge scientific or technical assumptions.

In STEAM, this might involve identifying real-world problems, exploring diverse contexts, or formulating hypotheses through structured curiosity.

2. Creative Thinking (from "Imaginative")

The capacity to generate new ideas by combining concepts, materials, and methods across disciplines—including the expressive and interpretative tools of the arts.

In STEAM, this takes shape when students use artistic strategies —such as storytelling, visual metaphor, performance, or sound design— to reframe scientific questions, humanize data, or give form to abstract concepts. Art becomes a medium for invention, helping to imagine futures, make sense of complexity, and communicate ideas in emotionally resonant ways.

3. Resilient Problem-Solving (from "Persistent")

A sustained commitment to tackling complex challenges, embracing ambiguity, and learning through iteration and failure.

This dimension emerges in repeated testing of ideas, adjusting solutions after unexpected outcomes, and refining processes through experimentation.

4. Interdisciplinary Co-Creation (from "Collaborative")

The ability to work meaningfully with others, bridging disciplinary boundaries and co-creating solutions that combine technical insight with artistic expression.

In STEAM, this dimension is especially powerful when students collaborate across roles —such as pairing coders with illustrators, or engineers with performers— to integrate artistic languages (visual, musical, narrative, spatial) into scientific or technological projects. The arts expand how problems are framed and how ideas are communicated, encouraging more inclusive, expressive and imaginative outcomes.

5. Rigorous Making (from "Disciplined")

The precise application of technical skills, critical thinking, and iterative improvement in the creation of tangible outcomes.

In practice, it appears in the careful construction of models, thoughtful application of methods, and clear documentation of processes.

Activity 5: Scientific Storytelling

Target group: Students

Objective: Reframe a scientific concept through storytelling or visual metaphor.

Description:
Students choose a scientific concept (e.g., climate change, cell division, black holes) and reimagine it as a short story, comic, or animation using artistic tools. They should explore not only the science behind the concept but also how to convey its emotional, ethical, or human dimensions creatively.

Materials:
Paper, digital drawing tools, storyboard templates, markers, voice recorders (optional)

This activity builds scientific understanding while fostering narrative skills, empathy, and imagination

Inter STEAM

STEAM (Science, Technology, Engineering, Arts, and Mathematics) offers a powerful framework for integrated learning. Although these five disciplines are united under one model, each has its own way of thinking and doing. Recognizing these differences is essential for building meaningful interdisciplinary learning experiences, especially when the goal is to actively challenge the gender stereotypes embedded in how each field is culturally and educationally perceived.

While Art has already been discussed as a natural connector between disciplines —offering expressive, reflective, and critical entry points— it is important to reaffirm that Art is also a STEAM discipline in its own right. It brings unique forms of inquiry, creativity, and cultural awareness that enrich the entire STEAM.

Student engagement with STEAM disciplines is not gender-neutral. As highlighted in the 2021 OECD report, in nearly all participating countries, women are the majority in fields related to health and well-being, yet they remain underrepresented in science, technology, engineering, and mathematics (Organisation for Economic Co-operation and Development [OECD], 2021).

Our own research, conducted through focus groups with educators, supports this finding. Teachers report observing these patterns in the classroom: girls are often more drawn to the health sciences, while boys are more encouraged —implicitly or explicitly— to explore technological or mathematical fields. These tendencies are reinforced by societal expectations, family influences, and the way each discipline is framed in the school context.

For this reason, working with STEAM from an interdisciplinary and gender-aware perspective means more than just combining subjects. It involves intentionally designing learning experiences that disrupt traditional gender roles, allow all students to explore all disciplines with equal confidence, and create a learning environment where creativity, logic, experimentation, and expression are not gendered traits, but shared human capacities.

Activity 6: BrainCircuits: The STEAM Game

Target group: Students 10-16 (design cards accordingly)

Objective: Travel through the five STEAM zones of the board, completing challenges, answering questions, and earning "Challenge Tokens" in each discipline. The first team to collect all five tokens AND complete the final task wins the quest to break the bias in STEAM!

Materials:

- A large printed gameboard or digital board (with 5 color-coded STEAM zones)
- Dice (1 per team)
- Challenge Cards (3–5 per area: S, T, E, A, M)
- Trivia/Knowledge Cards (quick questions per area)
- Role-Flip Cards (for reflective prompts)
- Challenge Tokens (printable icons or stickers)

Description:

Preparation

Divide students into mixed-gender teams (3–5 students). Each team needs:

- A team name
- A pawn or marker
- A challenge sheet (to track completed zones)
-

Game Flow

- Start on the center of the board.
- Teams take turns rolling a die and moving across the STEAM zones clockwise.
- Landing on a zone? Draw a card!
- Each space corresponds to one of three types of cards:
    - 🔧 Challenge Card: Creative task to complete in 5–7 minutes.
    - ❓ Trivia Card: Quick quiz or "taboo-style" activity.
    - 💬 Role-Flip Card: Discussion prompt about gender and stereotypes in STEAM.

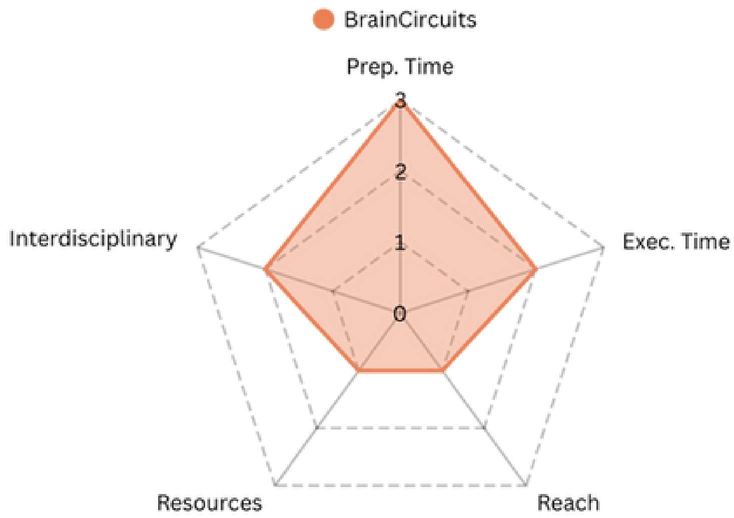
Example Cards

- Challenge Card: Act out a famous scientific discovery like a charade. Your team must guess the discovery and say who made it.
- Challenge Card: Using 5 straws and tape, build a bridge strong enough to hold a small object.
- Challenge Card: Describe "Architect" without using the words: building, house, plan, design, structure.
- Trivia Card: Who invented Wi-Fi technology? (Answer: Hedy Lamarr, actress and inventor)
- Role-Flip Card: Look at this stat: "Only 35% of STEM graduates in the EU are women." What does that mean for the workforce? Why might it be a problem? (Open discussion)
- Role-Flip Card: Think of a person in your life who breaks a stereotype. Share who it is and why.

Winning the Game

Each team earns a STEAM Token after successfully completing at least one challenge in each area. When they collect all five, they move to the "Bias Breaker" final zone, where they must:

- Collaboratively create a team slogan or banner that promotes equality in STEAM
- Present it to the class in under 2 minutes



Society and STEAM

Integrating STEAM pedagogy with the humanities and the broader context of society is not only a pedagogical priority but a necessary strategy to overcome persistent gender stereotypes and increase the inclusion of girls in STEAM fields. One of the key insights gathered from focus groups with students and educators is the cultural expectation that girls are more suited to the humanities, social sciences, or healthcare, and that STEAM subjects are perceived as "masculine" in both content and culture. These expectations reinforce social norms in ways that actively discourage girls' curiosity and confidence in technical and scientific domains. According to the American Association of University Women[31] (AAUW), this gendered perception is deeply rooted in societal stereotypes, underrepresentation, and the lack of visible female role models in science and technology —factors that continue to shape girls' learning pathways from an early age.

Society and STEAM

To transform this narrative, it is essential to integrate STEAM education into real-world, socially relevant contexts, including ethics, history, gender studies, and civic engagement. This integration helps students —particularly girls— recognise that science, technology, engineering, the arts, and mathematics are not isolated, abstract disciplines, but powerful tools for understanding, impacting, and transforming society. For instance, robotics can be taught not only through engineering and coding, but through its application in medical sciences —such as assistive technologies for elderly patients— or its ethical implications in labor, privacy, and social justice. Mathematics can be linked to social sciences through the statistical analysis of gender inequality, while data literacy can support critical thinking around media and misinformation. By embedding STEAM within socially relevant narratives and humanistic inquiry, educators make space for all pupils to see how their interests in care, communication, and culture intersect with fields like biotechnology, AI, or sustainable engineering.

Moreover, integrating STEAM with the humanities offers the opportunity to amplify the visibility of underrepresented voices and role models —past and present— who have used scientific and technical knowledge to address pressing social issues. Educators can highlight figures such as Rosalind Franklin, who contributed to the discovery of DNA, or Joy Buolamwini, who leads research on ethical AI and algorithmic bias, to show girls that STEAM disciplines can be powerful instruments of equity and justice. This interdisciplinary approach not only breaks down disciplinary silos, but it also humanizes science and technology, making them more relatable —and more empowering— especially for those who have historically been excluded. When girls see that they can pursue STEAM to solve problems they care about, rather than simply "be good at math or science," their sense of relevance, belonging, and motivation increases significantly. Integrating the societal dimension into STEAM learning is thus a key strategy in creating more equitable, inclusive, and meaningful education.

Activity 7: Tracking Time, Tracking Change

Target group: Students aged 12-14

Objective: Explore the historical timeline of major innovations, use mathematical reasoning to calculate time intervals between them, and reflect critically on how innovation is distributed and who benefits from it. The activity combines numeric skills with historical awareness and promotes discussion about equity in STEAM.

Description:

-**Select Innovation Milestones**

In groups, students choose at least five technological innovations from a provided list, or bring their own suggestions. Example milestones:

- Invention of writing – 3200 BCE
- Development of paper – 100 BCE
- Printing press – 1450 CE
- Steam engine – 1765 CE
- First man on the Moon – 1969 CE
- World Wide Web – 1989 CE
- Smartphone – 2007 CE

They place these innovations on a **horizontal timeline** —either drawn on paper or created using a digital tool.

-**Do the Math – Calculate Time Gaps**

Each group calculates the number of years between each pair of selected milestones. They must include at least one pair that spans from BCE to CE, so they practice working with both negative and positive numbers.

Example:

- From the invention of writing (3200 BCE) to the printing press (1450 CE):
- **3200 + 1450 = 4650 years**
- From the printing press (1450 CE) to the Moon landing (1969 CE):
- **1969 - 1450 = 519 years**

Students then answer:

- Which time gap was the longest?
- Which one was the shortest?
- Are innovations happening more quickly in recent centuries?

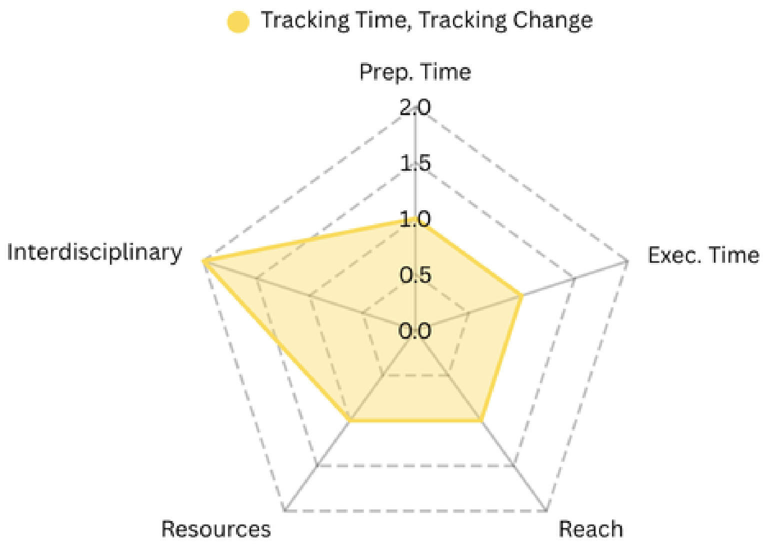
*Optionally, they represent the intervals **visually** as bar charts or line graphs to show how the pace of innovation has changed over time.*

-**Critical Reflection**

Students discuss:

- Why have innovations accelerated in recent times?
- Who drives innovation—and who benefits from it?
- Are there people or regions in the world today who still don't have access to recent innovations?
- How do we define "progress"? Can we measure it only in terms of speed?

You can guide this with prompts or invite students to add short written reflections to their final projects.



STEAM Beyond school

Preparing students for the future means going beyond subject knowledge. As the labour market becomes more dynamic and technology-driven, integrating STEAM (Science, Technology, Engineering, Arts, and Mathematics) with real-world professional contexts is key to building not only academic skills but also aspirations, awareness, and agency. By connecting classroom learning to meaningful careers, students begin to understand the “why” behind what they’re learning —and how their interests can translate into future opportunities.

STEAM education is not just about preparing students to become scientists or engineers. It’s about equipping them with a toolkit of transferable skills — creative problem-solving, collaboration, critical thinking, and adaptability— that are in high demand across sectors. Cultivating these skills must start early and be embedded across the curriculum in ways that are engaging, inclusive, and future-oriented[32].

Educators can foster this future-facing mindset by making careers visible, meaningful, and accessible. In our focus groups, one secondary school director emphasized the importance of starting early and building bridges between education and industry:

“Now, as director of this institute, which offers a lot of vocational training linked to industry, we've had an important initiative this year. We held two events where we invited primary students (fifth grade) together with our first-year students, and also invited companies. Through workshops and roundtables, we tried to show what industry is and that it needs everyone, regardless of gender or background... Often, we start too late.”

STEAM Beyond school

This testimonial highlights a key point: career orientation doesn't begin at the end of secondary school;it starts with visibility, relevance, and inclusive representation from the earliest years. That includes role models, mentors, industry partnerships, and activities that allow students to see themselves as future creators, technicians, innovators, or community problem-solvers.

Practical strategies to bring STEAM careers into the classroom:

- Invite local professionals (including alumni, family members, or company representatives) to speak about their work and answer student questions.
- Incorporate student-led projects where learners design, test, and improve their own solutions to real-world challenges.
- Create "junk engineering" challenges using recycled materials to simulate innovation under constraints, mirroring real design challenges in industries.
- Set up an "innovation corner" or maker space in the classroom where students can experiment, build prototypes, and collaborate.
- Assign classroom roles inspired by real jobs (e.g., project manager, data analyst, communicator, designer) to simulate workplace dynamics.
- Integrate challenge- or problem-based learning (PBL) tasks that mirror career fields—urban planning, environmental sustainability, assistive tech, etc.
- Use a "Genius Hour": dedicate time each week for students to explore their own questions or develop passion projects connected to STEAM and the world of work.

Each of these strategies helps students move from passive learning to agency-driven exploration, mirroring how professionals work, think, and collaborate. When students are given the freedom to explore careers through making, experimentation, and play, they begin to see STEAM not as abstract or "for someone else," but as something they can shape and belong to.

STEAM Beyond school

To ensure equity, it's essential that these career explorations include diverse voices, inclusive examples, and visibility of underrepresented groups in STEAM. As mentioned in earlier sections, building a sense of community —with the involvement of mentors, role models, and interdisciplinary collaboration— reinforces the message that the future of STEAM is for everyone.

Activity 8: Mapping the field

Target group: Students

Objective: Travel through the five STEAM zones of the board, completing challenges,
answering questions, and earning "Challenge Tokens"
in each discipline.
The first team to collect all five tokens AND complete the final task wins the quest to break the bias in STEAM!

Description:
Students investigate how physics is used beyond the classroom by searching for professionals and organizations on platforms like LinkedIn. They identify career paths, sectors, and projects where physics plays a key role—from space research and renewable energy to healthcare, art conservation, or data visualization. Based on their findings, students create a visual map or infographic that illustrates the diversity of physics applications in society.

Students can look into…

- Who works with physics in unexpected ways?
- What problems are they trying to solve?
- Where do they work?

Materials: Internet access, research notes template, tools for creating posters or digital visuals

This activity encourages students to see science as professionally diverse. It builds digital literacy, critical thinking, and awareness of how a specific discipline contributes to addressing real-world challenges

Activity 9: Interdisciplinary Approach Project

Target group: Students

Objective: Connect various STEAM disciplines between them and to professional contexts, integrating an artistic approach.

Description:

1. Warm-up: Breaking Stereotypes
Students analyze posters, ads, or websites about STEAM careers. In groups, they identify the gendered signals (e.g. colors, wording, job roles shown). Teachers facilitate a discussion on "Which careers are seen as male/female? Why?"

2. Research: Professions and Role Models
Each group selects a STEAM career area that is stereotypically gendered (e.g. "engineer" for boys or "nurse" for girls) and researches:

- Actual diversity in the field (statistics, trends)
- Challenges women, men, or non-binary people face in it
- Notable figures who break the mold

Optional: invite 2–3 guests with atypical profiles (e.g., female engineers, male nurses, queer tech creators) to talk to students about their paths.

3. Creative Re-Design: Future Profession Prototype
Students create a **<u>fictional "STEAM career of the future"</u>** that blends at least **<u>two disciplines</u>** (e.g., bio + AI, or design + engineering). Each group:

- Names the profession
- Designs a logo, uniform, or digital avatar
- Describes the skills required
- Writes an inclusive job description, avoiding gender-coded language

They can use digital tools (Canva, Scratch, 3D modeling apps) or analog materials (drawing, collage, performance).

4. Showcase: "Future STEAM Fair"
Groups present their prototypes to families and the school community. Peers and visitors vote on "most inclusive job", "most creative future tech", etc.

Creating an inspiring community

In order to break gender barriers in STEAM education, it is essential to recognize and mobilize the key actors who shape the learning journey and create the environment where young people form their identities, aspirations, and sense of belonging. These actors form an inspiring community that does not just deliver content but cultivates **purpose, confidence, and a vision for the future.**

At the heart of this community is the learner, who is not merely a passive recipient of knowledge, but a developing individual influenced by multiple forces. In the early stages of life, the learner relies on others to access knowledge, culture, and a sense of possibility. For this reason, the educational process must be seen as a shared responsibility: one that brings together the collective efforts of **families, educators, institutions, society, and role models.**

One of the main purposes of this methodology is building an ecosystem that inspires and sustains engagement through co-responsibility and connection. Education is not a one-directional effort; it is a network of relationships that must reflect diversity, inclusion, and encouragement, especially for girls and underrepresented groups in STEAM fields.

Families

Families are the first influence and source of motivation. Through their actions, values, and support, they shape how children perceive their own capabilities and potential pathways, long before formal education begins.

In our focus groups, participants repeatedly emphasized the critical role their families played in sparking early interest in STEAM and in shaping mindsets of curiosity, exploration, and resilience.

Modeling curiosity and hands-on learning at home

Several participants shared how their parents encouraged exploration through play, experimentation, and real-life problem-solving, far earlier than any formal exposure to STEAM subjects. For example, one teacher recalled:

"My parents were super supportive. They kind of just handed me a computer and let me play. That opportunity to explore on my own, rather than just being told what to do, was so important."

Others described growing up in homes where solving problems and building things together was part of everyday life:

"We were a family about problem-solving and flexible thinking. There was a lot of napkin drawing at the dinner table. My parents rarely said no —they were really good at finding creative solutions. That mindset shaped how I approach challenges even now."

This culture of curiosity, tinkering, and experimentation created fertile ground for STEAM-related thinking to grow organically.

Family members as professional role models

Many of the teachers we interviewed had family members, especially fathers, working in technical or scientific fields. Their presence not only normalized STEAM careers, but also inspired younger them to imagine themselves in similar roles:

"My father was an agronomical engineer. I wanted to see how things work and contribute to real progress, just like him."

"My dad was an engineer, and my brothers loved taking apart cars. That hands-on exposure at home was how I first encountered engineering, because school didn't offer any STEAM at the time."

Families

Even when schools lacked access or programs, families helped bridge that gap by providing exposure to engineering concepts and practices through everyday activities.

Parents enabling access and confidence

Parents also played a key role in providing access to tools, resources, or environments that allowed their children to build confidence in their abilities:

"My dad encouraged me toward this field, and over time I really started to like it. That encouragement was key."

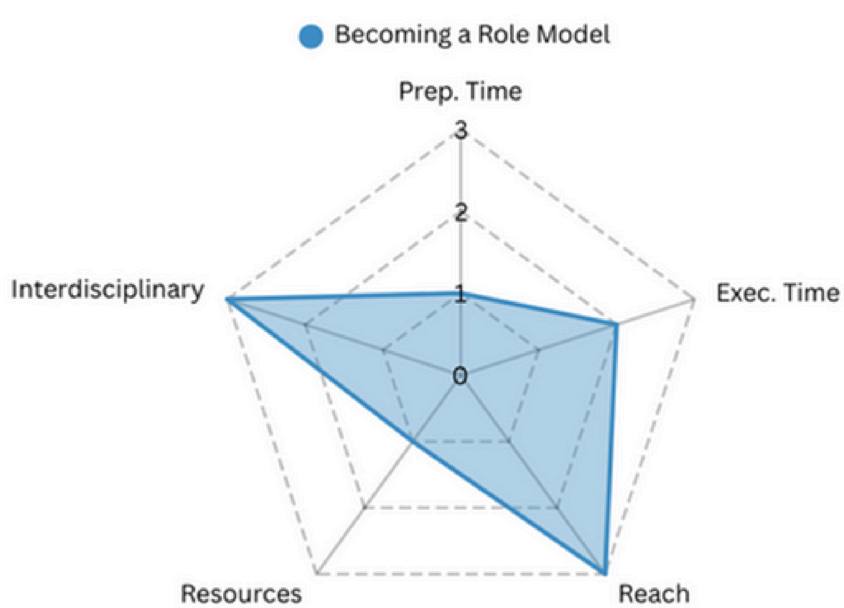
Supportive families not only recognized their children's interests, but actively nurtured them — whether by guiding educational choices, offering encouragement, or being present in moments of uncertainty.

Intergenerational influence and storytelling

Beyond actions, families also influenced through stories —sharing their own journeys, values, or professional paths. These stories helped demystify careers in STEAM and made them more tangible:

"I always talk about my professional journey with my students. But even before that, in my own life, it was the family first. First the family, then school."

These intergenerational narratives helped participants see how technical paths could align with purpose, creativity, and impact.



Activity 10: Becoming a Role Model

Target audience: Families (parents/guardians), during parent-teacher conferences or a specific tutorial session.

Objective: To raise awareness among family members about the critical role they play as early STEAM influencers and to encourage active involvement in their children's learning journeys.

Description:

Families will reflect on their role as potential STEAM role models. The session will include real-life testimonies, short inspirational videos, and collective discussions. Class tutors will guide participants through examples of simple actions that can spark curiosity and resilience in their children —like showing interest in homework, talking about their jobs and values, and promoting exploration at home.

1. Present short quotes or videos from other families on how they influenced their children's STEAM paths. Highlight diversity in experiences and backgrounds.
2. Small-group discussion: around the question *"What messages about learning or curiosity did you receive growing up? What messages do you think your children receive from you today?"*
3. **Action Planning:** Families brainstorm ways they can become everyday role models:
    - Asking their children about school projects
    - Sharing stories of overcoming problems at work or in life
    - Exploring "How does it work?" questions together
    - Being curious in front of their kids

Provide a simple checklist with ideas to reinforce STEAM mindsets at home, and questions they can ask to keep conversations going ("What did you discover today?" / "Can you teach me something new?")

Activity 11: Family experiences: Interview and Role-Play

Target audience: Students

Objective: To help students identify and reflect on personal role models within their family or close community and understand the power of storytelling in shaping aspirations.

Description:
This activity invites students to conduct a short interview with a family member who has inspired them—either through their job, their attitude, their creativity, or their values. The life with the broader idea of STEAM learning and professional identity.

1. **Pre-Interview Reflection (in class):**
   a. Discuss what makes someone a role model. Students list possible people in their family or environment they admire and prepare simple questions for their interview (e.g., What do you do? What did you enjoy learning when you were young? What challenges did you face?)
2. **Family Interview (at home):**
   a. Each student interviews their chosen role model using 3–5 guiding questions and takes notes or records the conversation with permission.
3. **Role-Play and Peer Interview (in class):**
   a. Students return to class and take turns embodying their chosen role model. In pairs or small groups, they role-play the interview, this time with classmates asking the questions. Interviewers might add new questions, and each student should answer "in character," as if they were the role model.
4. **Debrief Discussion:**
   a. The class reflects on what they learned about perseverance, creativity, or the connection between personal stories and STEAM careers. They can also discuss common values that emerged and how inspiration often comes from close to home.

Teachers as influence

Teachers are not just transmitters of content: they are important figures in shaping students' confidence, curiosity, and sense of belonging in STEAM. As mentors, gatekeepers, and role models, teachers influence how students perceive their own potential and the relevance of science, technology, engineering, arts, and math in their lives. Their attitudes, teaching styles, and inclusive practices can either open doors or reinforce existing barriers.

Guiding and supporting students

In our focus groups, many participants shared how their path into STEAM began with a teacher: someone who not only taught the subject but also believed in them, guided them, or simply modeled what it means to be passionate about learning.

"My role model was a woman who taught me in the ninth grade. Later, we were colleagues in the same classroom. She truly influenced my decision to go into a technical career."

"A mathematician made me. I didn't think math would be useful in life, but my teacher changed that. She made me want to know more, and that's how I started to enjoy computer science and ultimately chose a technical path."

"My math teachers, mostly women, were brilliant. I had doubts and diverse interests, but their classes sparked my passion. That's how I ended up choosing telecommunications engineering."

These testimonies highlight how representation, encouragement, and pedagogical approach can radically shift a student’s trajectory.

Collaboration with families

While teachers hold significant influence over students, their role can extend beyond the classroom to impact families as well. In many cases, teachers are the bridge between families and STEAM: helping parents understand how to support their children’s interests, breaking down stereotypes, and opening up conversations about future possibilities

Participants in our focus groups emphasized that collaboration with families is essential, especially when working with diverse social backgrounds. Rather than perceiving parents as “outsiders” or obstacles, teachers must approach them as potential allies in a shared mission to cultivate curiosity, confidence, and opportunity in young learners.

“We need to stop seeing parents as opponents. We come from different social backgrounds, yes, but we must open dialogue, avoid stigmatization, and collaborate—even if everything’s not perfect. The key is the will to work together.”

By modeling curiosity, inclusiveness, and communication, teachers can also inspire parents to engage more actively in their children's learning, regardless of their own academic background.

- **Communicate beyond academic results:** Share positive observations about the child's creativity, problem-solving, or interests—not just test scores. Help families see the strengths that might align with STEAM potential.
- **Educate families about STEAM opportunities:** Many parents are unfamiliar with the range of STEAM-related careers and pathways. Teachers can share stories, videos, or student projects that illustrate the relevance and accessibility of these fields.
- **Invite families into the learning process:** Include them in science fairs, student exhibitions, or STEAM project days. Ask them to contribute stories, skills, or even challenges from their own work or daily life.
- **Normalize trial-and-error and curiosity at home:** Encourage families to let children experiment, ask questions, and explore outside of grades and performance. Provide tips for promoting inquiry and resilience in everyday activities.

Activity 12:
Fear-Free STEAM Conversations

Target audience: Students
(optional: involve families)

Objective: To normalize feelings of doubt or anxiety related to STEAM subjects (e.g. math anxiety), create a safe space for open dialogue, and promote strategies for overcoming learning insecurities.

Description:

Anxiety related to subjects like math or science often emerges from fear of failure, comparison with others, or rigid ideas of who is "good" at certain things. By acknowledging these feelings collectively, students learn they are not alone—and that mistakes and confusion are natural parts of learning.

1. **Opening Question**: On slips of paper or anonymously via an online form, ask students to respond to:
   - *"What's something in math or science that makes you feel nervous, confused or stressed?"*
   - *"What helps you feel better when something feels hard?"*

Collect the responses and read a few aloud (anonymously), making connections and normalizing those feelings.

Use affirming language like: "This is more common than we think." / "It's totally okay to feel that way." / "Even scientists and engineers feel stuck sometimes."

2. **Group Reflection**: Discuss common beliefs identified in the answers shared by students, such as:
   - *"Some people are just born good at math."*
   - *"If I don't get it right the first time, I'm not smart enough."*
   - *"Others are faster, so I must be bad at it."*

As a class, write "myths" on one side of the board and rewrite them into positive, realistic "truths" together. Example: **Myth**: *"You need to be fast to be good at math."* → **Truth**: *"Thinking deeply takes time. Speed is not the same as understanding."*

3. **STEAM Confidence Map**: Each student draws a simple 3-part chart, using traditional artistic tools or digital platforms (p.e Canva):

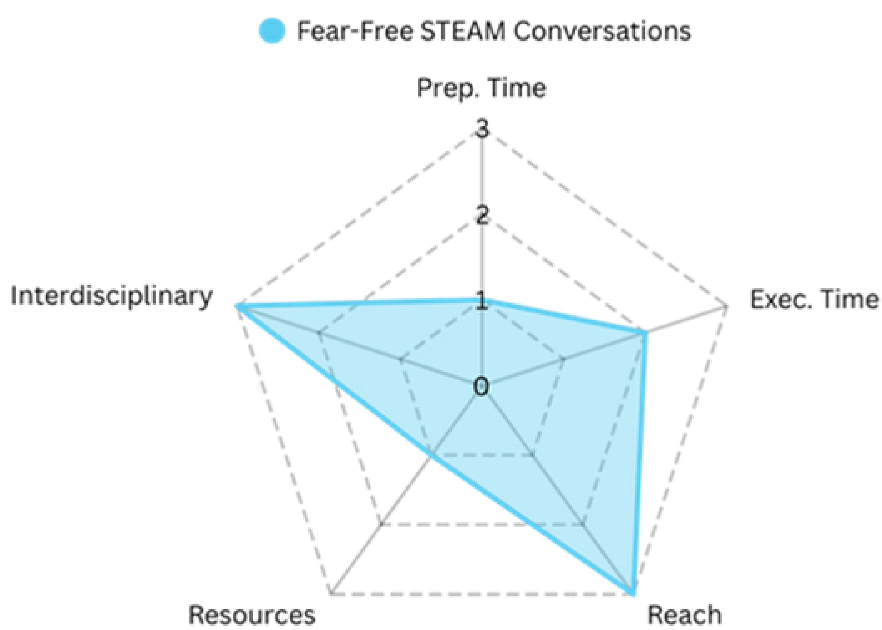
- *"What I feel confident about in STEAM?"*
- *"What I find hard or confusing?"*
- *"What I'd like to get better at?"*

They reflect individually and then pair up with a classmate to share one thing from each column (optional sharing in small groups).

4. **Class Agreement on Learning Support**: Together, the class co-creates 3–5 "learning values" or supportive phrases to display on the classroom wall. Examples:

- *"We celebrate trying, not just getting it right."*
- *"It's okay to ask twice—or five times."*
- *"Helping each other helps us all."*

5. **Family follow-up (optional)**: Invite families to continue the conversation at home by sending a reflection prompt like: *"Talk to your child about something you struggled with in school and how you overcame it."* Link this to previous work on how to become a role model at home.



Activity 13: The Learning Maze: Overcoming Together

Target audience: STEAM teachers from the same grade level and students from the classes in that grade.

Objective: To explore common emotional obstacles in STEAM learning—like math anxiety, fear of failure, or comparison with others—through a symbolic, collaborative activity that reinforces the idea that learning is a shared, supported journey.

Description:

1. **Preparation:** STEAM teachers meet to co-design the Learning Maze, a circuit made up of several emotion-themed stations. Each station represents a typical emotional barrier in STEAM learning. For example:
   - "The Wall of Mistakes" → A challenge that requires multiple failed attempts (e.g., assembling a puzzle with missing pieces). Focus: frustration, resilience, learning from error.
   - "Comparison Mirror" → Students read common self-defeating thoughts like "Everyone else is better than me" and work together to rewrite them into positive or neutral phrases.
   - "Tunnel of Not Knowing" → A riddle or question based on unfamiliar content. Focus: embracing uncertainty and curiosity, being okay with not knowing yet.
   - "Bridge of Asking for Help" → To move forward, groups must ask another student or teacher for help. Focus: normalizing help-seeking and interdependence.

Each teacher leads one station, focusing on emotional reflection over task completion.

2. Playing (students)

Step 1: Form Mixed Groups

Students from different classes are grouped together in teams of 4–6.

Step 2: Travel the Maze

Each group rotates through 3–4 stations. At each stop:

- They complete the symbolic task
- Reflect briefly on what it made them feel
- Collect a keyword, drawing, or symbol to represent what helps them learn better (e.g., "support", "bravery", "asking questions")

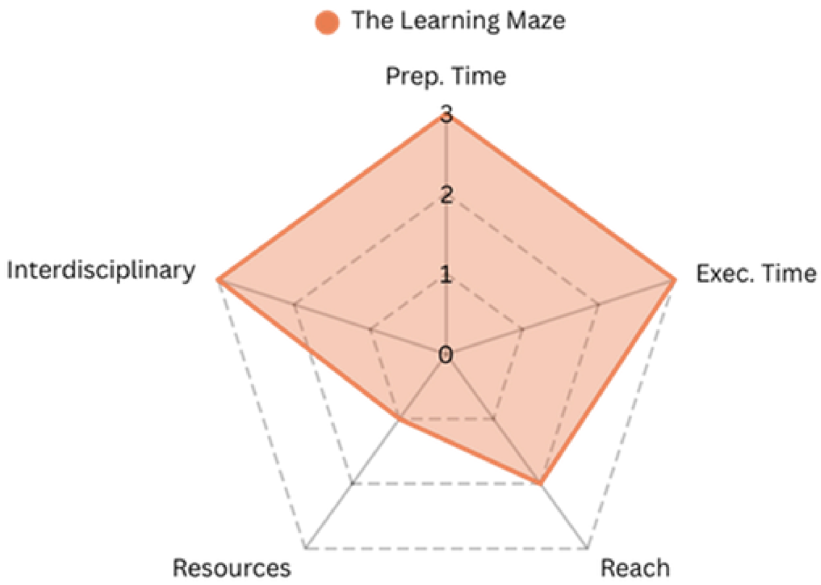
Step 3: Collective Closure

All groups gather in a shared space and add their keywords or symbols to a big mural or poster titled: "What We Need to Learn With Confidence".

Teachers facilitate a closing circle with questions like:

- What emotions came up during the maze?
- What helped you feel safe or encouraged?
- What should we keep doing as a learning community?

The mural becomes a visible commitment to emotional well-being in STEAM learning. It can be displayed in hallways or classrooms and revisited throughout the school year as a reminder that growth comes through connection, not competition.



Society and role models

Students' sense of possibility is shaped not only by what they learn in school, but also by the people they see around them, the stories they hear, and the opportunities they have to connect with the world outside the classroom. Role models —whether famous, local, or part of the school community— help students visualize themselves in STEAM fields. They make abstract futures feel concrete, personal, and achievable.

Making success visible

In our focus groups, participants emphasized the importance of introducing students to real people who work in STEAM: people who love what they do and who can speak honestly about their journey. These encounters were described as moments that could "unlock" something in students, especially when they broke stereotypes or came from relatable backgrounds.

"Involving children from an early age in these fields in an active rather than theoretical way, laboratory courses, educational visits and discussions with professionals in the field who can transmit to children their love for what they do."

"When Samantha Cristoforetti came to speak to students, it was a giant step: she showed that a career in space is possible."

Society and role models

Hearing stories of women in STEAM —especially those who have overcome obstacles, changed direction, or combined science with creativity— helps students broaden their view of who belongs in these fields. Highlighting a wide range of role models also helps challenge persistent gender and cultural stereotypes, and shows that there are many paths to success.

Exposure to role models broadens students' understanding of what STEAM can look like. It challenges stereotypes, introduces new aspirations, and strengthens the message that success in science, technology, engineering, arts, and mathematics comes in many forms. By doing activities where students have to do research and connect to stories of real people, they also connect emotionally with their journeys.

Activity 14: STEAM Spotlights: Building Our Role Model Gallery

Target group: Students

Objective: To help students discover and share stories of diverse STEAM role models, while fostering a sense of connection, representation and collective inspiration.

Description:

1. **Teacher-led spotlight**

Start with a short weekly or monthly session where you introduce a STEAM figure. Use a story, short video, or image-rich presentation. Focus on:

- Who they are
- What they do or did
- What challenge they faced
- Why their story matters

Encourage discussion: What surprised you? What values does this person represent?

2. Student-led research

Each student chooses a STEAM role model—famous, local, historical, or contemporary. Encourage diversity in gender, ethnicity, background, and fields. Research can be done during class or at home. They create a short, creative presentation using one of the following formats:

- Poster or timeline
- Illustrated biography
- Comic strip or storyboard
- Short video or audio recording

Some prompts to guide their work may be:

- What inspired this person?
- What barriers did they overcome?
- How does their work connect to your life or interests?

3. Classroom exhibition

Students present their role models in small groups or a whole-class gallery walk. Allow time for peer questions and reflections.

Optional: let students vote on a "Spotlight of the Month" to highlight in the hallway or on the school's website.

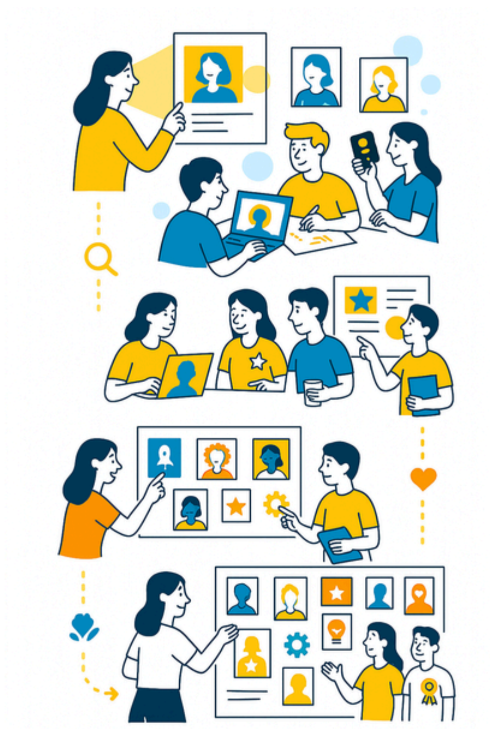
4. Create a growing gallery

Display the student work on a designated wall, bulletin board, or digital space under the title: **"STEAM is for Everyone: Our Role Model Gallery"**

Keep adding new stories throughout the term or school year to build a shared archive of inspiration.

Optional Extensions:

- Encourage students to be creative on how to conduct their research. For example, invite them to interview someone in their community (e.g. a family member, local professional)
- Combine the gallery with mentorship sessions or guest visits from selected role models
- Turn the final gallery into a printed or digital booklet to share with families and future students



Society and role models

Learning through mentorship and dialogue

Beyond visibility, students also need spaces to talk, ask questions, and share their uncertainties. Mentorship, whether formal or informal, offers a powerful way to build motivation and confidence. It gives students the chance to connect with someone who listens, who shares their experiences, and who helps them see their own potential.

" I would say in general, it's always good to have someone that can be a sounding board and that you can speak to about your questions. So I think it's positive. Any support you can give to a youngster growing and going through questioning is useful."

Mentorship doesn't have to involve a long-term program. Even a single conversation can have an impact when it's honest, warm, and responsive to the student's needs. Schools can organize short "speed mentoring" events, invite alumni or professionals for classroom visits, or create informal lunch talks where students are encouraged to ask real questions and reflect on the answers.

Another effective format is to organize a panel with alumni or professionals followed by small-group conversations. After listening to different life stories, students rotate between guests in short sessions, asking questions like: What helped you when you were unsure? What do you enjoy most about your work? What do you wish you had known at my age?

Activity 15: Speed Mentoring: Ask Me Anything

Target group: Students aged 13–18

Objective: To connect students with diverse STEAM role models through dynamic, small-group conversations that foster curiosity, confidence, and a sense of shared community.

Description:

1. Invite the role models

Identify 4–6 people connected to the school or community who can share their personal journey related to STEAM. These could be:

- Local professionals
- Family acquaintances or friends of students
- Former students or alumni
- Volunteers or community figures
- People who may not work directly in STEAM but use STEAM-related skills in creative ways

Diversity of backgrounds and experiences is more important than status or fame. Let them know they are not expected to "give a speech," but to have honest, informal conversations.

2. Prepare the students

In a short preparatory session, explain the goal of the activity and what to expect. Encourage students to prepare 2–3 personal questions such as:

- *Have you ever felt unsure about your path?*
- *What helped you keep going?*
- *What do you like most about what you do?*
- *Did you imagine yourself doing this when you were younger?*

Remind them that the objective is not to impress, but to listen, connect and learn from others' experiences.

3. Speed mentoring session (approx. 1 hour)

Organize the space so that each role model sits at a table. Students rotate in small groups (3–5 per group), spending 7–10 minutes at each table. During this time, they ask questions, listen to stories, and exchange reflections.

Use a bell or soft signal to mark the change between rounds. Provide optional prompt cards on each table in case conversation slows down.

4. Shared reflection

After the rounds, all students and role models gather in a closing circle or large group setting. Together, they share final thoughts:

- What stood out?
- What did we learn from one another?
- What do we take with us from this experience?

Allow both students and guests to speak freely or write a word or phrase that sums up the experience. This shared reflection transforms the activity into a collective moment of connection and reinforces the message that learning happens in community.

Society and role models

Connecting to the real world

Finally, bringing students into real STEAM environments helps them connect what they learn with how it's used in the world. Whether through visits to labs, studios, workshops, companies, or universities, these experiences make learning visible, physical, and relevant.

"I advocate for interdisciplinary projects, practical workshops, and experiential activities: activities should allow children to express creativity and find their own solutions rather than follow rigid instructions."

When students visit a workplace or meet professionals in context, they see STEAM as something dynamic and useful—not just theoretical or abstract. These encounters help answer questions like: What do people in STEAM actually do every day? What kinds of skills matter? What does success look like up close?

By opening up the classroom to role models, mentors, and real-world experiences, we create an ecosystem that supports belonging, ambition, and connection. Students not only learn what's possible—they start to believe that it's possible for them.

Society and role models

Building a STEAM-inspired community:

- Mentorship to drive motivation: connect students with mentors —alumni, professionals, or older peers— to offer guidance, encouragement, and space for reflection.
- Highlighting role models in class: share stories of pioneers, innovators, and diverse professionals to expand students' perception of what success looks like in STEAM.
- Organizing events with community involvement: create fairs, exhibitions, or STEAM days that bring together families, professionals, and local organizations to celebrate learning.
- Alumni talks and networking sessions: invite former students to share their journeys, offer advice, and engage in dialogue with current learners.
- Study visits and mentoring with professionals: provide students with real-world exposure to STEAM environments through visits or virtual encounters.
- Intergenerational learning experiences: promote encounters between younger and older students who share their STEAM-related interests, questions, or projects.

Informal spaces for dialogue and inspiration: set up "curiosity cafés", lunch talks, or co-creation workshops where role models and students can interact in relaxed, meaningful ways.

Final Reflections: A Path Forward for STEAM Teaching

This methodological handbook has been designed with one clear purpose: to empower educators with practical, creative, and inclusive strategies to teach STEAM in a way that is hands-on, meaningful, and connected to the real world. Our approach is grounded in the belief that learning by doing —through experimenting, playing, and creating— is not only more engaging, but also more effective in helping students build lasting knowledge, confidence, and motivation.

Throughout this guide, we have pursued three core goals. First, to provide clear, ready-to-use instructions that teachers can easily bring into their classrooms, regardless of their background in STEAM. Second, to promote an interdisciplinary vision of STEAM that integrates the arts and connects science and technology to social issues, ethics, and students' own lived experiences. And third, to create an inspiring community around students, where families, teachers, role models, and peers work together to make STEAM education inclusive, motivating, and relevant to all learners.

From exploring how societal expectations shape student interests, to offering playful and project-based activities that connect STEAM to future careers, this framework reflects a commitment to equity and creativity.

STEAM is not just a set of subjects —it is a lens through which students can explore, question, imagine, and build a better future. And with the right tools, guidance, and community, every educator can help them get there.

References

[1] STEM Women. "Women in STEM Statistics: Progress and Challenges." Accessed July 30, 2025. https://www.stemwomen.com/women-in-stem-statistics-progress-and-challenges.

[2] Tilbrook, Ned, and Dara Shifrer. 2021. "Field-Specific Cultural Capital and Persistence in College Majors." Social Science Research 103 (October): 102654. https://doi.org/10.1016/j.ssresearch.2021.102654.

[3] Middleton, T. (2025, April 17). What is teamwork and why is it important? - Work Life by Atlassian. Work Life by Atlassian. [2] Tilbrook, Ned, and Dara Shifrer. 2021. "Field-Specific Cultural Capital and Persistence in College Majors." Social Science Research 103 (October): 102654. https://doi.org/10.1016/j.ssresearch.2021.102654.)

4] Center for Social and Cultural Psychology, KU Leuven & Greenlight for Girls (2018). Impact Project Research Report (2015–2018). https://ppw.kuleuven.be/cscp/research/greenlight-for-girls-en, Leuven, Belgium.

[5] Ranken, Emily, Dominic Wyse, Yana Manyukhina, and Alice Bradbury. 2024. "The Effect of Experiential Learning on Academic Achievement of Children Aged 4–14: A Rapid Evidence Assessment." The Curriculum Journal, October, 1–18. https://doi.org/10.1002/curj.304.

[6] Näslund-Hadley, Emma, Rosangela Bando, and Paul J. Gertler. 2018. "Inquiry and Problem Based Pedagogy: Evidence from 10 Field Experiments." IDB Working Paper 958, Inter-American Development Bank, October. https://doi.org/10.18235/0001491

[7] Akhigbe, J. N., & Adeyemi, A. E. (2020). Using gender responsive collaborative learning strategy to improve students' achievement and attitude towards learning science in virtual and hands-on laboratory environment. Journal of Pedagogical Research, 4(3), 241-261.

[8] Putra, Maulana Dias, Wiyanto Wiyanto, and Suharto Linuwih. 2020. "The Effect of Discovery Learning on 21st Century Skills for Elementary School Students." Journal of Primary Education 9, no. 2 (March): 201–208. https://doi.org/10.15294/jpe.v9i2.37349

[9] Kapur, Manu. 2008. "Productive Failure." Cognition and Instruction 26, no. 3 (July): 379–424. EJ800999. https://eric.ed.gov/?id=EJ800999.

[10] Alfi, Orit, Idit Katz, and Avi Assor. 2004. "Learning to Allow Temporary Failure: Potential Benefits, Supportive Practices and Teacher Concerns." Journal of Education for Teaching: International Research and Pedagogy 30, no. 1 (April): 27–44. https://doi.org/10.1080/0260747032000162299.

[11] Metcalfe, Janet. 2017. "Learning from Errors." Annual Review of Psychology 68 (January): 465–89. https://doi.org/10.1146/annurev-psych-010416-044022.

[12] Kehoe, Rachel. 2020. "A Secret of Science: Mistakes Boost Understanding." Science News Explores, September 10, 2020. https://www.snexplores.org/article/secret-science-mistakes-boost-understanding.

[13] Dorland, AnneMarie. 2023. "Failing to Learn: Design Thinking and the Development of a Failure-Positive Mindset in the University Classroom." Collected Essays on Learning and Teaching 14, no. 1 (June 6): n.p. https://doi.org/10.22329/celt.v14i1.7155

[14] Darwich, Lina, Dennis DeBay, Lisa Forbes, and Julia Mahfouz. 2025. "Play, Reflect, Cultivate Social and Emotional Learning: A Pathway to Pre-Service Teacher SEL through Playful Pedagogies." Frontiers in Education 9 (2024): Article 1478541 (published January 8, 2025). https://doi.org/10.3389/feduc.2024.1478541

[15] The LEGO Foundation. "The Scientific Case for Learning through Play." Learning Through Play, March 2024. https://learningthroughplay.com/explore-the-research/the-scientific-case-for-learning-through-play.

[16] Waldman-Levi, Amiya, Anita Bundy, and Dana Shai. 2022. "Cognition Mediates Playfulness Development in Early Childhood: A Longitudinal Study of Typically Developing Children." American Journal of Occupational Therapy 76 (5): 7605205020. https://doi.org/10.5014/ajot.2022.049120

[17] Education Endowment Foundation. “Play-Based Learning.” Early Years Toolkit, 2021. https://educationendowmentfoundation.org.uk/early-years/toolkit/play-based-learning.
[18] Li, Xiaoyan, and Marjaana Kangas. 2024. “A Systematic Literature Review of Playful Learning in Primary Education: Teachers’ Pedagogical Activities.” Education 3–13: International Journal of Primary, Elementary and Early Years Education, 1–16. https://doi.org/10.1080/03004279.2024.2416954.
[19] Skovbjerg, Helle Marie, Julie Borup Jensen, Line Togsverd, Oline Pedersen, Helle Hovgaard Jørgensen, Vibeke Schrøder, Mikkel Snorre Wilms Boysen, Ole Lund, Jeppe Bundsgaard, Bent Sortkær, and Mona Have Nielsen. 2024. Playful Learning Dissemination Report: A Report on Research in Playful Approaches to Teaching in Social Education and Teacher Training. 1st ed. Kolding, Denmark: Playful Learning. https://playful-learning.dk/wp-content/uploads/2024/08/Skovbjerg-et-al.-2024-PlayfulLearning_Dissemination-report_pages.pdf.

[20] Papert, Seymour, and Idit Harel. "Situating Constructionism." In Constructionism, edited by Idit Harel and Seymour Papert, 1–11. Norwood, NJ: Ablex, 1991.
[21] Li, Jiajia, Suilin Goei, and Rongjin Huang. 2024. “Unveiling Maker Mindsets: A Journey of Formation and Transformation through Design Thinking-Making Pedagogy within a Lesson Study Context.” Frontiers in Education 9 (April 9): Article 1343492. https://doi.org/10.3389/feduc.2024.1343492.
[22] Cotnam-Kappel, Megan, Alison Cattani-Nardelli, Sima Neisary, and Patrick R. Labelle. 2024. “The Design and Implementation of Maker Projects in Elementary Schools: A Scoping Review.” Canadian Journal of Learning and Technology 50, no. 4 (November): 1–24. https://doi.org/10.21432/cjlt28608

[23] Dike, Ibwari Caroline, Mkpoikanke Sunday Otu y Adannia Amalachukwu Dike. 2024. “Effect of Hands-On Instructional Approach on Pupils’ Achievement and Retention in Cultural and Creative Arts.” International Journal of Professional Business Review 8, no. 12: e04207. https://dialnet.unirioja.es/descarga/articulo/9298115.pdf.
[24] Price, Sara. 2013. Designing ‘Tangibles’ for Learning: An Empirical Investigation (IOE Research Briefing No. 62). London: Institute of Education, University of London, November. https://discovery.ucl.ac.uk/1525513/1/RB62_Designing_Tangibles_for_Learning_Price.pdf
[25] MakerEd. 2019. Approaches to Maker Education: A Resource for Educators (version 6). Maker Education Initiative, September. https://makered.org/wp-content/uploads/2019/09/MakerEd_Resource_Approaches_v6.pdf
[26] Li, Jiajia, Suilin Goei, and Rongjin Huang. 2024. “Unveiling Maker Mindsets: A Journey of Formation and Transformation through Design Thinking-Making Pedagogy within a Lesson Study Context.” Frontiers in Education 9 (April 9): Article 1343492 (1–18). https://doi.org/10.3389/feduc.2024.1343492.

[27] https://www.washingtonpost.com/news/innovations/wp/2014/09/05/stem-is-incredibly-valuable-but-if-we-want-the-best-innovators-we-must-teach-the-arts/
[28] Sternberg, R. J. (1999). Intelligence as developing expertise. Contemporary Educational Psychology, 24(4), 359–375.
[29] Gardner, H. (2005). Inteligencias múltiples: La teoría en la práctica. Barcelona: Paidós.
[30] Lucas, B. (2016). A five-dimensional model of creativity and its assessment in schools. Applied Measurement in Education, 29(4), 278–290. https://doi.org/10.1080/08957347.2016.1209206

[31] Lucas, B. (2016). A five-dimensional model of creativity and its assessment in schools. Applied Measurement in Education, 29(4), 278–290. https://doi.org/10.1080/08957347.2016.1209206

[32] Hill, C., Corbett, C., & St. Rose, A. (2010). Why so few? Women in science, technology, engineering, and mathematics. Washington, DC: American Association of University Women.https://www.aauw.org/app/uploads/2020/03/why-so-few-research.pdf

[33] Firmansyah, & Aslan. (2025). The relevance of STEAM education in preparing 21st century students. International Journal of Teaching and Learning (INJOTEL), 3(3), 9–16https://injoqast.net/index.php/INJOTEL/article/download/50/28

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