# STEAM roadmap for Science Education in Horizon Europe

Deliverable 5.1

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| Grant Agreement Number | 101058405 |
| Project Acronym | Road-STEAMer |
| Project title | Developing a STEAM Roadmap for Science Education in Horizon Europe |
| Start date of the project | 01/09/2022 |
| Duration of the project | 36 months |
| Due Date of Deliverable | 30/04/2025 |

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| Version | 1.0 |
| Dissemination Level | Public |
| Project website address | [www.road-steamer.eu](http://www.road-steamer.eu) |



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# Revision History

| Revision | Date | Author | Organisation | Description |
|---|---|---|---|---|
| 0.1 | 14/02/2025 | Sabrina Bresciani | PO | Initial draft |
| 0.2 | 16/03/2025 | All authors | PO, LC, EA, ZSI, SV | Second version |
| 0.3 | 14/04/2025 | Luca Lazlo, Petra Van Haren, Elisabeth Unterfrauner, Marta Anducas, Francesco Mureddu | ESHA, ZSI, LC | Reviewers' comments |
| 0.4 | 24/04/2025 | Sabrina Bresciani, Sunit Joseph, Annalisa Addis, Elena Silvestrini | PO LC | Final draft |
| 1.0 | 28/04/2025 | Annalisa Addis, Francesco Mureddu, Elena Silvestrini, Sabrina Bresciani, Sunit Joseph | LC | Revision, final formatting and pdf submission |

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## List of Abbreviations

| Abbreviation | Description |
|---|---|
| AI | Artificial Intelligence |
| EA | Ellinogermaniki Agogi |
| EC | European Network Science Centres and Museums (Ecsite) |
| ENG | Engineering Ingegneria Informatica |
| ESHA | European School Heads Association |
| EU | European Union |
| FP10 | Framework Programme 10 |
| GDPR | General Data Protection Regulation |
| K-12 | Kindergarten to 12th grade – compulsory education range in United States and Canada |
| LC | The Lisbon Council for Economic Competitiveness and Social Renewal asbl. |
| OECD | Organisation for Economic Co-operation and Development |
| PAN | Panteion |
| PO | Politecnico di Milano |
| STEAM | Science, Technology, Engineering, Arts and Mathematics |
| SV | Science View |
| TR | TRACES |
| UM | University of Malta |
| UoE | The University of Exeter |
| WP | Work Package |
| WP1 | Coordination and support for dialogue and mutual learning work package |
| WP2 | STEAM context, concepts and conditions work package |
| WP3 | Analysis of STEAM policy gaps and needs work package |

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| WP4 | The landscape of STEAM practices work package |
| WP5 | Synthesis of the STEAM roadmap work package |
| WP6 | Dissemination and Exploitation work package |
| WP7 | Management work package |
| ZSI | Zentrum für Soziale Innovation |

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|---|---|
| DEAP | European Union’s Digital Education Action Plan (2021-2027) |
| OECD | Organisation for Economic Co-operation and Development |
| STEM | Science, Technology, Engineering, Mathematics |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| DG RTD | Directorate-General for Research and Innovation |
| DG EAC | Directorate-General for Education and Culture European Commission |
| DG EMPL | Directorate-General for Employment, Social Affairs and Inclusion |
| DG CONNECT | Directorate-General for Communications Networks, Content and Technology |

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# Abstract

This report constitutes Deliverable 5.1 of the Road-STEAMer project, titled “STEAM Roadmap for Science Education in Horizon Europe”. The Road-STEAMer project, which will end in August 2025, aims at developing a STEAM roadmap for science education in Horizon Europe: a plan of action that will provide guidance to EU's key funding programme for research and innovation on how to encourage more interest in STEM through the use of artistic approaches, involving creative thinking and applied arts (the “A” in ‘STEAM’).

This deliverable outlines the first version of the elaboration of the roadmap, aimed at proposing strategies and concrete actions to promote science education mainstreaming in funded projects in various European Union funding streams, focussing primarily on inputs for the tenth Framework Programme for Research and Innovation (FP10). The intended audience for this roadmap and deliverable are policy makers, in particular officers in charge of the implementation of the EU STEM Education Strategic Plan and of the Union of Skills, and more broadly those working in areas that stand to benefit from improved STEAM education and uptake of STEAM related careers. More specifically, we identify action items for the following Directorate-Generals of the European Commission: Research and Innovation (DG RTD); Education, Youth, Sport and Culture (DG EAC); Employment, Social Affairs and Inclusion (DG EMPL), and Communications Networks, Content and Technology (DG CNECT).

The purpose of this first version is to collect feedback and further refine the plan which will be published in the second version of the roadmap in Deliverable 5.2 due in August 2025. The second version of the roadmap in the next deliverable will also contain a discussion of feasibility and possible impacts of the strategy. The roadmap is summarized in an interactive visual on which readers can directly provide feedback. It outlines four key priority areas:

1) strengthening the STEAM curriculum at national and EU level (redefine STEAM as a holistic curriculum; develop STEAM learning materials and teacher resources);

2) enhancing teacher training and the learning environment (prioritize STEAM training for educators; foster inclusive and supportive learning environments harnessing AI and digital tools);

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3) STEAM literate citizens - aligning STEAM education and career design with societal and industrial needs (STEAM career design and integrated learning pathways; encourage agile partnerships with Industry and organizations to address industrial and societal needs);

4) transdisciplinary, effective inclusive STEAM education paradigms promoting equity (flexible, inclusive and supportive STEAM education; Promote intersectional approaches in STEAM, improving accessibility).

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# Introduction

## About Road-STEAMer and this deliverable

The overall aim of the project is to develop a STEAM roadmap for science education in Horizon Europe: a plan of action that will provide guidance to EU's key funding programme for research and innovation (namely Horizon Europe and the forthcoming FP10, but also other funding streams such as Erasmus+,and others) on how to encourage more interest in STEM through the use of artistic approaches, involving creative thinking and applied arts (the “A” in ‘STEAM’). This deliverable presents and outlines the first version of this roadmap, proposing strategies and specific actions to integrate science education into funded projects across various EU policy areas and to align STEAM education with societal and industrial needs. The roadmap will be further refined and finalised in Deliverable D5.2 (due by August 2025). Both deliverables sit within Work Package 5, whose work covers the synthesis of project results, the elaboration of the roadmap, and the analysis of its feasibility.

The roadmap has been collectively created through collaboration with the stakeholder communities of education and science education, research, innovation, and creativity, through workshops, dialogues and feedback sessions. Further evidence is provided through 14 foresight workshops and 5 stakeholder dialogues, adding a foresight dimension with a 2035 timeframe to align STEAM education with society’s and industry’s expectations, involving formal and informal science education as well as stakeholders with diverse abilities and accessibility to provide an inclusive perspective.

The roadmap builds and synthesises the work done in the project’s previous deliverables (in particular synthesizing the work of WP2 on STEAM context, concepts and conditions, WP3 analysis of STEAM policy gaps and needs, and WP4 identification of synergies across the education continuum and businesses). The analysis, recommendations and contributions of projects funded under the same call, SEER and SENSE.STEAM, are mapped and referenced through the roadmap, through continuous dialogues and mutual learning which will be reflected in the STEAM atlas of roadmaps headed by the project SEER. The results are synthesized in a roadmap provided in a visual and interactive version as well as a textual version, with all actions outlined in Section 2.2 of this deliverable.

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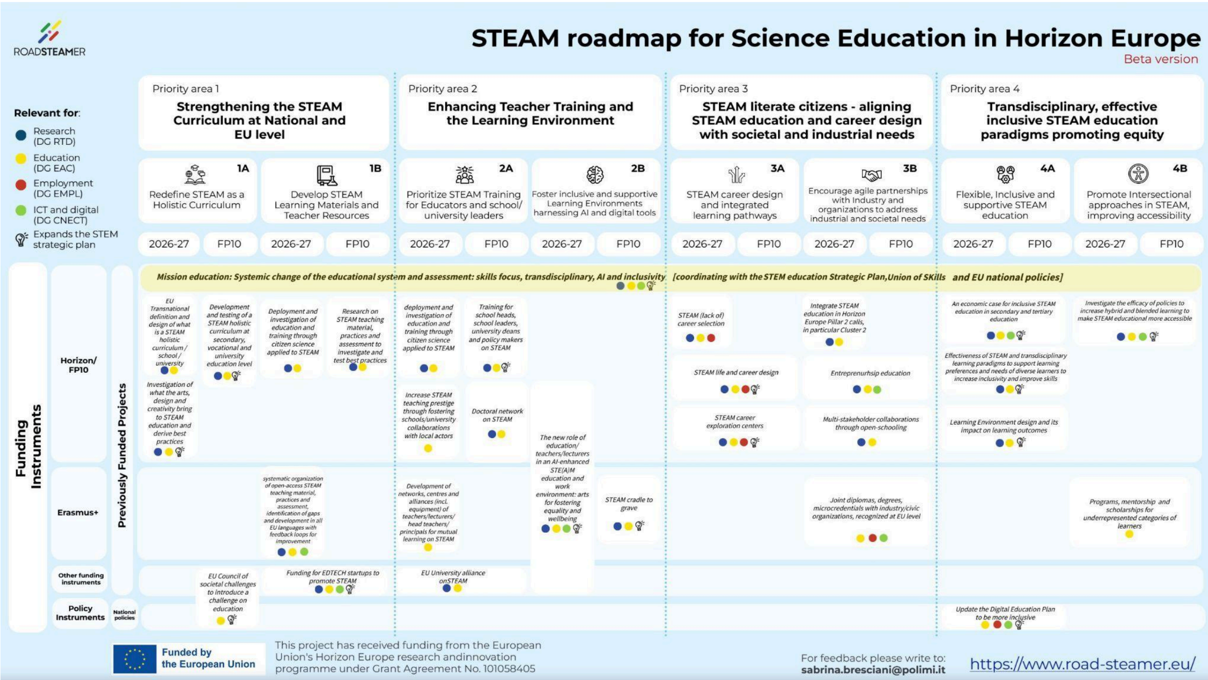


Figure 1: Screenshot of the interactive version of the roadmap

The actions of the roadmap are color coded according to the potentially most interested intended audience: Directorate-General for Research and Innovation (DG RTD), Directorate-General for Education and Culture European Commission (DG EAC), Directorate-General for Employment, Social Affairs and Inclusion (DG EMPL) and Directorate-General for Communications Networks, Content and Technology (DG CONNECT). For each single action, the relation to the STEM Education Strategic Plan is made explicit - showing if the action supports the STEM Education Strategic Plan indicated actions (thus providing further examples, indications and suggestions), or if it expands the the STEM Education Strategic Plan by providing additional actions (such as career centers, life and career design, hybrid teaching through AI, building an economic case for inclusive STEAM education, etc.).

The roadmap is aligned with EU priorities and strategic documents on STEM education, in particular on the JRC document "STEM competencies, challenges, and measurements: a literature review (Joint Research Centre, Mazzeo Ortolani, Pokropek et al., 2024), which provides a very detailed in-depth analysis of STAM and STEM education, aligning with EU priorities of stimulating European competitiveness (Letta, 2024; Draghi, 2024). The document reports the rising need of STEAM specialists in the EU and of STEAM research, highlighting that "about 75% of STEM education research originates from the USA, with a significant lack of evidence from the European Union (EU). Furthermore, nearly half of the publications are not research articles but discussions or summaries that do not significantly contribute to scientific knowledge in the fields" (pg. 5). The STEM Education Strategic Plan, builds on those insights and further highlights a decline of 7% in doctoral graduates in STEM fields in the EU while they have grown in the USA (16.3% in 2015-2022) and even more in China and India (2020) (pg.4). The JRC document reports that many students across the EU fail to achieve minimum proficiency levels in key Science, Technology, Engineering, and Mathematics (STEM) areas, particularly mathematics and science, as well as highlighting the shortage of qualified mathematics and science teachers at all educational stages (JRC et al. 2024). The same report highlights that "Integrated STEM and STEAM (adding arts) approaches are becoming more common, focusing on developing skills such as creativity and problem-solving. Although integrated STEAM approaches are appealing and theoretically sound, they are defined and applied inconsistently. This complicates curriculum design, evaluation, and scientific studies." (Pg. 46). The report concludes with a call for more research on the topic. Our roadmap also aligns with the JRC Science for Policy Brief "STEM

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and STEAM education, published in April 2025, and proposed additional innovative actions and directions.

The European Union's latest Skills Agenda, which is also linked to the European Digital Strategy, emphasizes that "90% of all jobs will soon require some level of digital skills, yet 40% of Europeans lack these skills entirely" (pg. 12), while acknowledging that STEM skills are critical to drive the twin transitions (pg. 13). The global pool of STEM graduates is concentrated in large economies. European nations like Germany, the UK, and France produce a significant number of STEM graduates but lag behind global leaders such as China and India, which also deploy STEAM approaches (I.e., India's 2020 National Education Policy includes STEAM promotes labs in schools, and China's C-STEAM educational approach that integrates traditional Chinese culture into STEAM curricula). At a global level, a study by the Organization for Economic Cooperation and Development (OECD) "Getting Skills Right" predicts that many of the jobs in highest demand today will disappear by 2030 and be replaced by jobs directly or indirectly related to the STEM fields.

## Structure of this Deliverable

This deliverable is structured in 2 main chapters, followed by Conclusions and an Appendix. **Chapter 1 provides the synthesis of the methodologies utilized to develop the roadmap:**

**Section 1.1** describes STEAM education, its definition and scientific evidence - synthesizing the work of WP4.

**Section 1.2** outlines the ecosystem and current context of STEAM education - synthesizing the work of WP2 and more recent developments of the implications of AI for education.

**Section 1.3** provides the synthesis of policies contexts and gaps in the EU - synthesizing the work of WP3 and resulting policy recommendations.

**Section 1.4** maps an analysis of the EU funding schemes in STEAM education (Horizon and Erasmus+).

**Section 1.5** is dedicated to the description of the insights on STEAM foresight to 2035 derived from 12 workshops and 4 dialogues with the project stakeholders conducted with the roadmapping technique.

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**Section 1.6** syntheses all the work done in a matrix of priority areas and funding instruments, and reports on the results of two workshops with projects funded under the same call (SENSE and SEER - with their deliverables also mapped), and with EU policy makers of DG EAC, DG CNECT and DG RTD-REA.

Then, **Chapter 2** **presents the actual roadmap**:

**Section 2.1** provides a visual map of the roadmap in the form of an interactive matrix, outlining the main dimensions of 4 priority areas and the funding instruments: Horizon and FP10, Erasmus+, and others.

In **Section 2.2** each single action is explained in detail, providing a brief description, references of examples and projects for each action, evidence from academic literature, deliverables and other projects, as well as its relation to the STEM Education Strategic Plan indicating if the action *supports* or expands it.

The **Appendix** provided additional information summarizing the key deliverables: A: Project participatory approach and methodology; B: STEAM Policies and analysis, C: STEAM context, concepts and conditions; D: AI and education; E: Funding opportunities specifically for AI and education.

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# 1. Methodological steps

## 1.1. STEAM education

Given that the aim of Road-STEAMer is to promote STEAM education across Europe, it is important to spend a few words on what this acronym refers to, acknowledging that there is not a unique definition. At a minimum, STEAM aims at the integration of 'the arts' within the more established STEM acronym, which refers to Science, Technology, Engineering, and Mathematics - although it must be noted that multiple interpretations exist regarding what constitutes STEM education itself (JRC et al., 2024), some of which do not involve the integrated presence of all four disciplines (Martín-Páez et al., 2019). This underscores the need for a clearer and more consistent definition of STEM and STEAM education in academic literature (Razi & Zhou, 2022). According to the literature review produced in this project (Yeomans et al., 2023; Yeomans et al., 2025), definitions of STEAM and its related education also vary. STEAM is a relatively new interdisciplinary/transdisciplinary methodology, with the academic literature only emerging in the last decade (Aguilera & Ortiz-Revilla, 2021). However, as Colucci-Gray et al. (2017) note, much of the extant STEAM literature suffers from a lack of conceptual clarity as to what STEAM is. This may be partially attributed to the lack of consensus as to how STEAM is defined and what the purpose is of the 'A', or 'the arts', within the STEAM framework. According to Perignat and Katz-Buonincontro (2019), there is a tendency for researchers and practitioners to begin with the relationship between the disciplinary components of STEAM, i.e., the sciences, technology, engineering, arts, and maths, followed by the classification of STEAM as interdisciplinary, transdisciplinary, multi-disciplinary, or cross-disciplinary. The incongruity then lies in how these varying definitions are used to identify a practice as 'STEAM' (Chappell & Hetherington, 2023; Chappell et al., in review).

The systematic review of the literature developed in this project (Yeomans et al., 2023; Yeomans et al., 2025) identified 26 frameworks utilized for STEAM studies and clustered them into a theoretical classification system with four distinct theoretical approaches to STEAM Education: 'experiential real-world interactions', 'human psychological and cognitive', 'social, spatial, and material interconnectivity', and 'cultural and equity'. A visualisation (Fig 2) provides insights into the variety of theoretical and methodological paradigms utilized for STEAM studies.

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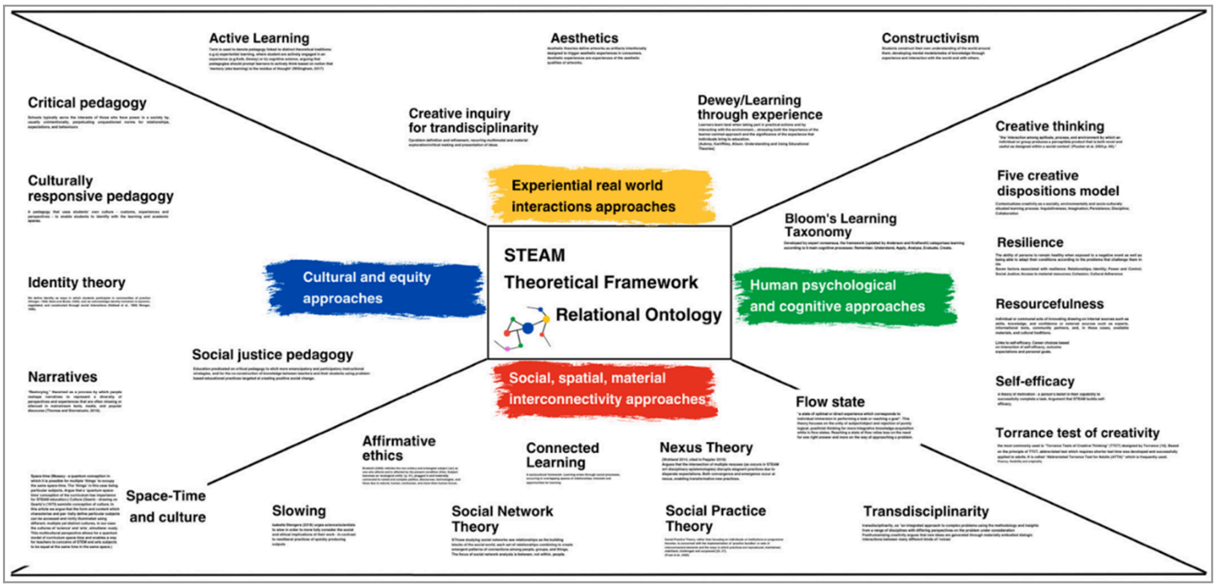


Figure 2: The STEAM theoretical framework relations ontology developed in this project
(Source: Chappell & Hetherington, 2023; Chappell et al., in review)

This classification system was intended to complement further work undertaken in this project (Chappell & Hetherington, 2023; Chappell et al., in review) which analysed existing practices and resources to articulate and understand the criteria that might be used to search out and collate strong STEAM practice and synthesise this into viable practice and policy recommendations. This framework was developed from a structured literature review, producing the following characteristics: equity as an all-pervasive characteristic; disciplinary inter-relationship particularly acknowledging the arts' contribution; collaboration; involvement of real-world connections; the processes of thinking-making-doing; creativity; and inclusion, empowerment and personalisation. These are shown together in Figure 3.

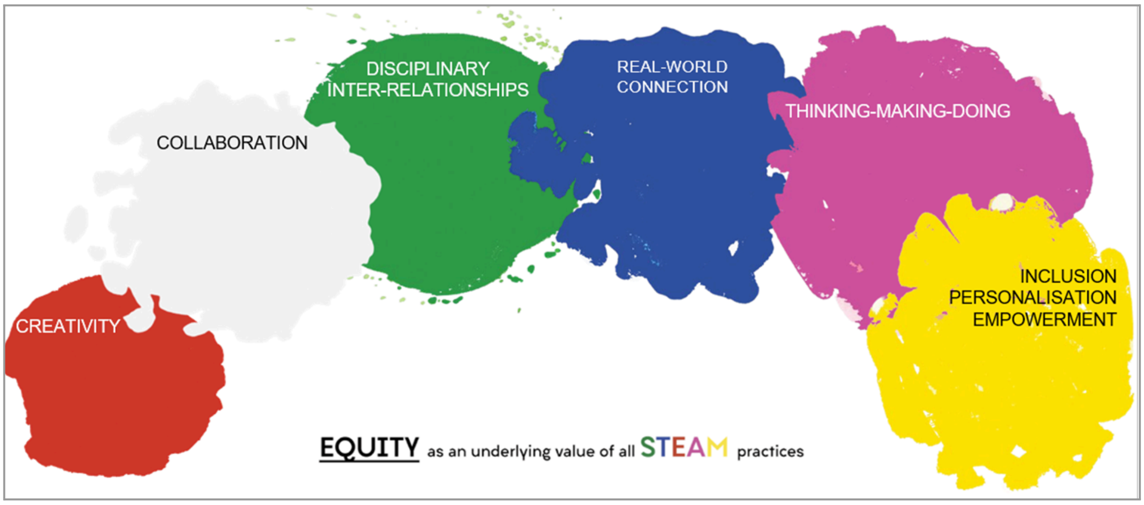


Figure 3: The Road-*STEAMer* project criteria *(D4.1)*

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Firstly, 110 STEAM projects and practices were collected of which 65 selected and mapped in an interactive geographic map of STEAM practices available on the project website (Fig 4).

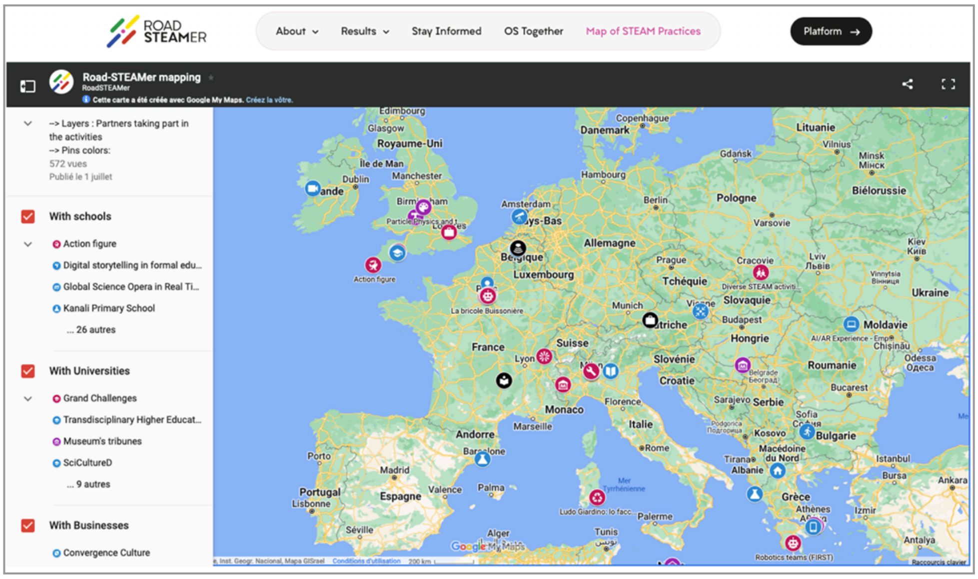

Figure 4: *The Road-STEAMer interactive map of STEAM projects and practices*

Secondly, the Road-STEAMer project demonstrates the relationship between the criteria (Fig 3) and their manifestation within STEAM projects and practices (Fig 4). It has therefore developed a methodology which involves drawing on the above Road-STEAMer characteristics to structure a comprehensive questionnaire for gathering detailed descriptions of EU STEAM practices. Responses to this questionnaire from selected 40 STEAM projects were synthesised and visualised as ‘radar diagrams’ see an example in Figures 5 and 6. The radar diagrams synthesise multiple criteria into visual representations of characteristics, facilitating comparative analysis and insights into the effectiveness of STEAM practices, which are connected to understanding their ability to address wicked problems across Europe.

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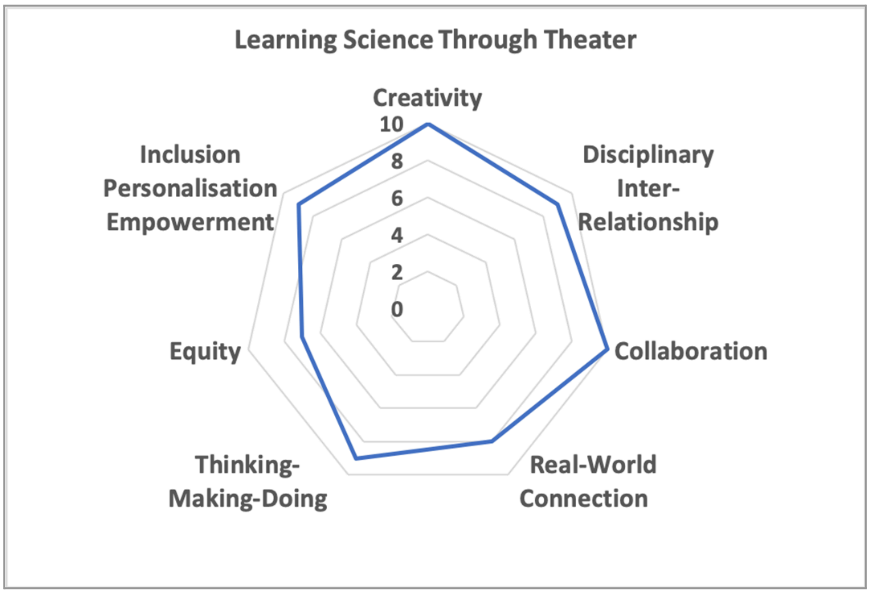


Figure 5: Radar diagram of Learning Science Through Theater evaluated according to the criteria

Figure 5 shows an application of the criteria for evaluating the initiative of "Learning Science Through Theater" which bridges secondary and tertiary education by facilitating dialogue between school students and academics. In the radar diagram above, 'creativity' was given the maximum score because of the effective integration of science and theory, allowing participants to gain knowledge in both disciplines as well as other interdisciplinary skills. The lower score in 'equity' was given because of the difficulty of replicating this initiative without being part of the project, as doing so would require substantial resources.

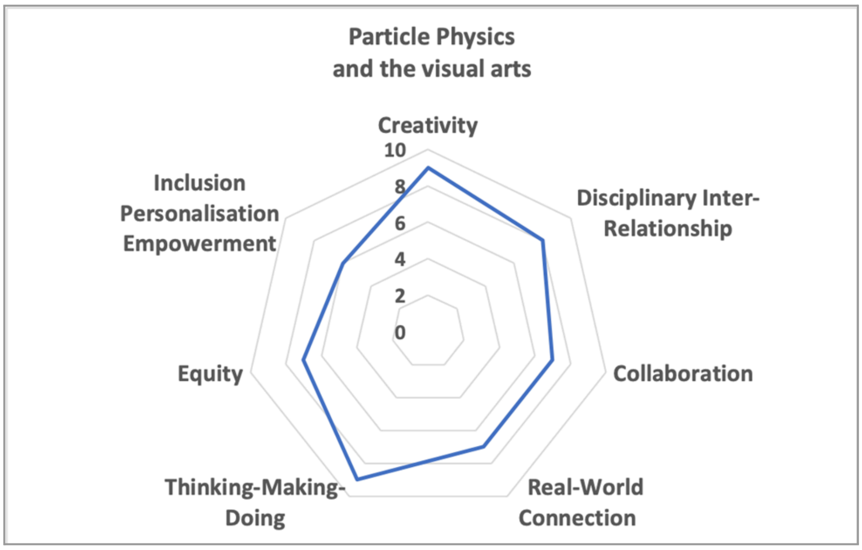


Figure 6: Radar diagram of Particle Physics and the visual arts evaluated according to the criteria

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Figure 6 outlines the evaluation of the project "the community arts group In-Public" which is a collaboration with the University of Birmingham particle physics group to develop a series of practical workshops for primary and secondary schools. The workshops utilise the interrelationship between drawing, photography, sculpture and performance and offer an "art school" experience for students, pupils and adults as well as introducing particle physics. The 'creativity' and 'Thinking-Making-Doing' aspects of this practice are very strong, for this reason. However, there is no policy in place to reach those less likely to participate and workshop accessibility is limited, therefore 'equity' received a lower score. More information about these projects as available through an interactive map of STEAM practices.

## Current Trends in AI in Education Research

While the original scope of the Road-STEAMer project did not explicitly include references to large language models (LLMs) and other forms of so-called Artificial Intelligence (AI), recent developments in this domain are having an impact on educational systems that cannot be left unexamined. It is well documented that the use of AI in education has increased from 2004 to 2023, with a peak after 2019 and the release of ChatGPT and other Generative AI tools (D'Angelo et al., 2024). Similarly, current trends in AI in education show a significant increase in research and application, particularly in primary and secondary education, with an increase in the number of educational AI studies in 2021 and 2022 for AI technologies implementation (Crompton & Burke, 2023). The largest world economies have already embedded AI into the traditional curriculum. Over the past decades, research on AI in education focused primarily on the technology aspect and goals such as academic prediction, dropout prevention, learning analytics and data mining, learning performance, personalized learning environments, adaptive assessment tools, and intelligent tutoring systems (Li & Tanenbaum, 2023, Rissanen, 2024). With the pervasive role of AI applications in everyday life, though, that mediate our social, cultural and political interactions (Rahwan et al., 2019; Webb et al., 2020) and the wide range of sectors AI is implemented (e.g., healthcare, education, sustainable development) (Vinuesa et al., 2020), concerns have been raised on the limitations and the challenges of AI particularly regarding the societal and ethical implications. The overarching trend in AI education policies is the promotion of human-centred, ethical, and inclusive approaches that balance technological advancements with societal well-being, ensuring AI benefits students, teachers, and the broader society and economy. The future needs for AI Education in the EU emerging seem to be:

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- Scaling of AI competency frameworks for educators and students to ensure broad and pedagogically valid adoption,
- Integration of ethical and responsible AI into Curricula, embedding values such as human rights, equity, and sustainability principles,
- Increasing investments in AI driven learning environments particularly for underrepresented regions and target groups, through targeted funding (AI in STEAM),
- Strengthening socio economic inclusion and ensuring AI education policies promote equal opportunities and prevent biases in AI applications,
- Collaboration between policy, research, and industry by enhancing partnerships between academic institutions, policy bodies, and tech companies to advance AI in education.

The EU is already funding several projects on AI in education (i.e., DRONE; AI4GOV), although not specifically in relation to STEAM. A more detailed discussion of EU funds on AI in education is provided in Appendix E.

## 1.2. Current context of STEAM education: the ecosystem - conditions are requirements

STEAM education operates within a multifaceted ecosystem influenced by socio-economic, educational, and industry factors. Based on literature review and secondary data analysis as well as a co-creation workshop with partners, the Road-STEAMer project team has gained comprehensive insights into these dynamics, shedding light on critical socio-economic contexts and the pressing needs for the development and inclusivity of STEAM in Europe published in Deliverable 2.3, in Unterfrauner et al., 2024, and summarized in this section.

### Socio-Economic Influences on STEAM Participation

STEAM participation is notably impacted by socio-economic conditions. Families' educational and science capital play significant roles in determining students' engagement and success in STEAM fields (Seebacher et al., 2021; Morgenroth, et al., 2015). Higher socio-economic status families often provide enriched environments conducive to educational attainment, offering support such as assistance with homework, access to extracurricular resources, and exposure to science and technology activities (Jordan, 2010). These advantages contribute to higher academic performance and foster an early interest in STEAM subjects, which can lead to sustained engagement and eventual career pursuits in related fields (cf. Gorard & See, 2009).

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Conversely, students from lower socio-economic backgrounds face compounded barriers that impede their academic achievements and limit their future opportunities in STEAM. These barriers include limited access to quality educational resources, extracurricular learning opportunities, and parental support, which collectively contribute to lower academic performance and reduced motivation (Archer et al., 2012). Research highlights that socio-economic disparities manifest early in educational settings, with significant achievement gaps in mathematics and science observable as early as elementary school (e.g. Betancur et al., 2018, Niu, 2017). Such early disparities tend to widen as students progress through their educational journeys, creating long-term impacts on their choices and success rates in higher education and STEAM careers (Betancur et al., 2018).

The relationship between family income, parental education, and student achievement underscores the need for early intervention. Policies aimed at reducing socio-economic disparities must focus on creating supportive and inclusive learning environments (Gorard & See, 2009). This includes targeted funding and resources for schools in disadvantaged areas, programmes that engage parents and communities, and strategies that provide equal opportunities for all students to access STEAM education and extracurricular activities (Leslie, 2020). Addressing these challenges at the foundational level can help bridge the gap and create more equitable outcomes in STEAM education.

## Inclusion and Diversity in STEAM

Diversity in STEAM education remains a pivotal challenge that requires sustained efforts to overcome. Factors such as gender, ethnicity, socio-economic background, and cultural identity intersect to create barriers that deter underrepresented groups from pursuing STEAM studies and careers (Votruba-Drzal et al., 2016; Niu, 2017). Gender stereotypes, for instance, continue to influence girls' participation in science and mathematics (Makarova et al., 2019). Despite incremental improvements over the years, significant gaps persists, especially in fields like engineering, computer science, and certain technology sectors (EC, 2022). These gaps are at first sight a result of individual choices but at second sight, are clearly shaped by broader societal influences, including media portrayals, school curricula, and the availability of relatable role models as well as structural barriers (Niu, 2017).

Efforts to deconstruct these stereotypes and foster broader participation have proven effective in increasing engagement and retention. Initiatives that showcase diverse role models, employ inclusive teaching methods, and integrate real-world applications of STEAM concepts help reshape students' perceptions and build confidence (Childs et al., 2015;

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Hofstein & Kesner, 2015). Programmes that highlight diversity including various genders, ethnic minorities, having diverse abilities and disabilities, and individuals from diverse socio-economic backgrounds in STEAM can inspire underrepresented groups to envision themselves in similar roles. Additionally, fostering a classroom culture that values inclusivity and encourages participation from all students helps counteract feelings of exclusion and the belief that "science is not for me."

Cultural identity and family expectations also play significant roles in shaping students' attitudes toward STEAM subjects (Archer et al., 2012; Falk et al., 2016). In many communities, the perception of STEAM as an elite or inaccessible field can discourage participation. Addressing these cultural barriers requires community-based outreach, partnerships with local organisations, and culturally responsive pedagogy that resonates with students' backgrounds and experiences (McDool and Morris, 2020; Rheinschmidt & Mendoza-Denton, 2014). When students see their identities reflected in the curriculum and teaching approaches, they are more likely to engage meaningfully and pursue further education and careers in STEAM.

## Industry Needs and the Demand for STEAM Skills

The current pace of technological advancement and the ongoing transformation brought about by the Fourth Industrial Revolution underscore the critical need for a workforce equipped with comprehensive STEAM skills. Industry demand for individuals proficient in STEAM is not limited to technical expertise; it also extends to the integration of transversal skills such as creativity, critical thinking, and intercultural communication (EC JRC, 2020; JRC et al. 2024). These competencies are becoming increasingly vital as industries navigate complex challenges that require innovative solutions and interdisciplinary approaches.

The combination of technical and non-technical skills is essential for preparing students to thrive in a rapidly changing job market. The need for digital literacy and technological fluency is evident across all sectors, as businesses seek employees who can adapt to new tools, think creatively, and collaborate effectively. However, there is often a disconnect between the skills taught in educational institutions and those required by employers. This mismatch poses challenges for both graduates entering the job market and industries seeking skilled talent (Penprase, 2018).

Educational institutions must adapt their curricula to balance technical and transversal skills, promoting interdisciplinary learning that bridges the gap between theoretical knowledge and

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practical applications in the sense of open schooling approaches ("Open learning and open schooling are broad terms which describe learning which is 'open' in terms of timing, location, teaching roles, instructional methods, modes of access, and any other factors related to learning processes", Make it Open, nd, p.5). Collaborations between schools and industries can facilitate this shift, ensuring that students gain exposure to real-world problems and hands-on experiences. For instance, partnerships that involve guest lectures, internships, and project-based learning can provide students with insights into industry expectations and practical applications of their education. Beyond technical proficiency, industries are increasingly prioritising employees who possess a strong sense of social responsibility and the ability to approach technological challenges ethically. This trend highlights the importance of creative, interdisciplinary and collaborative approaches in STEAM education, fostering well-rounded individuals capable of understanding and addressing the human and societal impacts of technological advancements. Policies that encourage cross-sector collaborations and innovative teaching practices will be key in aligning educational outcomes with industry needs and preparing the next generation of STEAM professionals.

The COVID-19 pandemic reinforced the need for resilient educational systems that adapt to disruptions while maintaining educational continuity. It brought attention to digital inequalities and emphasised the necessity for widespread digital literacy and flexible teaching methods. Moreover, the pandemic underscored the value of interdisciplinary approaches, showcasing how scientific literacy can empower societies to respond effectively to complex challenges.

## 1.3. Current context and gaps in policies on STEAM

Despite growing recognition of the value of STEAM approaches, especially in addressing complex societal challenges, its integration into educational policy remains rather limited.

As highlighted in deliverable 3.1 Analysis of STEAM policy gaps and needs, the "Science Education for Responsible Citizenship" report (2015) had laid the foundation for promoting STEAM education at EU level, focusing on key areas like establishing a learning continuum, transitioning to STEAM, and fostering collaboration among stakeholders. However, subsequent policy documents have reverted back to STEM as the main frame of reference. Sporadic mentions of "STEAM" and integration of artistic perspectives usually appear instrumental, i.e. as a way to make STEM disciplines appealing to female students given their persistent underrepresentation in those fields. A notable example is the Digital Education Action Plan (2021-2027), which only refers to STEAM as a way to tackle gender

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disparities in STEM.The same is true of national educational policies across member states (and beyond), given that "STEM" remains the main focus, even when the actual contents of the policy could possibly fall under "STEAM" according to the Road-STEAMer criteria. For this reason we refer to "STEAM", as the "A" is not always explicitly acknowledged[1].

It is worth noting that the recently launched STEM Education Strategic Plan (2025), despite opting for the STEM acronym rather than STEAM, appears to push for a more comprehensive approach that acknowledges the importance of interdisciplinarity, and the links between strictly speaking STEM fields and creative industries.

Overall, as detailed in D3.1 and in Road-STEAMer's second policy brief, Europe is generally lacking in mainstreaming STEAM education. Nonetheless, across the continent there is a growing number of initiatives that go towards more holistic educational approaches, often linked to digital education and skills, as testified by the results of the mapping carried out as part of WP2. Despite the diversity of approaches, it is possible to identify a number of countries that are making significant progress towards STEAM, in particular Belgium, France, Bulgaria, Finland, and Germany, which have implemented long-term strategies, specific action plans, and initiatives to promote STEM and integrate arts and humanities. A second and larger group of countries have made some progress in promoting STEAM education, but are still facing challenges such as teacher training, resource allocation, and improving integration of arts and humanities into STEM. Such countries include Austria, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Italy, Latvia, Lithuania, Malta, the Netherlands, Poland, Romania, and Spain. Other member states are further behind in the development of policy initiatives to prioritise STEAM. Beyond the EU, we have also examined the cases of the UK, which maintains a strong focus on STEM, and of Ukraine which, despite the ongoing war, has embraced a more holistic approach to modernize its education system with a strong focus on digitalisation.

Further analysis of the policy gaps related to STEAM education has centered around three dimensions (D3.2):

- STEAM curriculum:

[1] It is relevant to note that for people whose main language is not English, both STEM and STEAM may simply be perceived as foreign words, without a clear link to the disciplines that the acronyms are meant to stand for. In this context, STEM can simply signify anything that is science-related, from the more traditional lessons to innovative educational practices that we would categorise as STEAM.

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    - Existing policies often have a narrow focus on STEM, neglecting the importance of arts and humanities.
    - There's a need for policies that promote a holistic STEAM curriculum, emphasizing collaboration, interdisciplinary learning, and real-world connections.

- STEAM context:
    - Current policies don't adequately address the need for strong learning environments and well-prepared educators.
    - Policies should promote autonomy, flexibility, and innovation in educational settings.
    - Teacher training and professional development should be prioritized to equip educators with the necessary skills.

- STEAM agenda:
    - Existing policies often focus on using STEAM to promote STEM-related goals, particularly attracting women to STEM fields.
    - A more comprehensive approach is needed to address a wider range of societal and industrial needs, as well as equity issues.

Overall, the analysis reveals a lack of comprehensive policies that support a holistic approach to STEAM education. There's a need for policies that address all three dimensions and promote STEAM as a valuable tool for addressing societal challenges and preparing students for the future.

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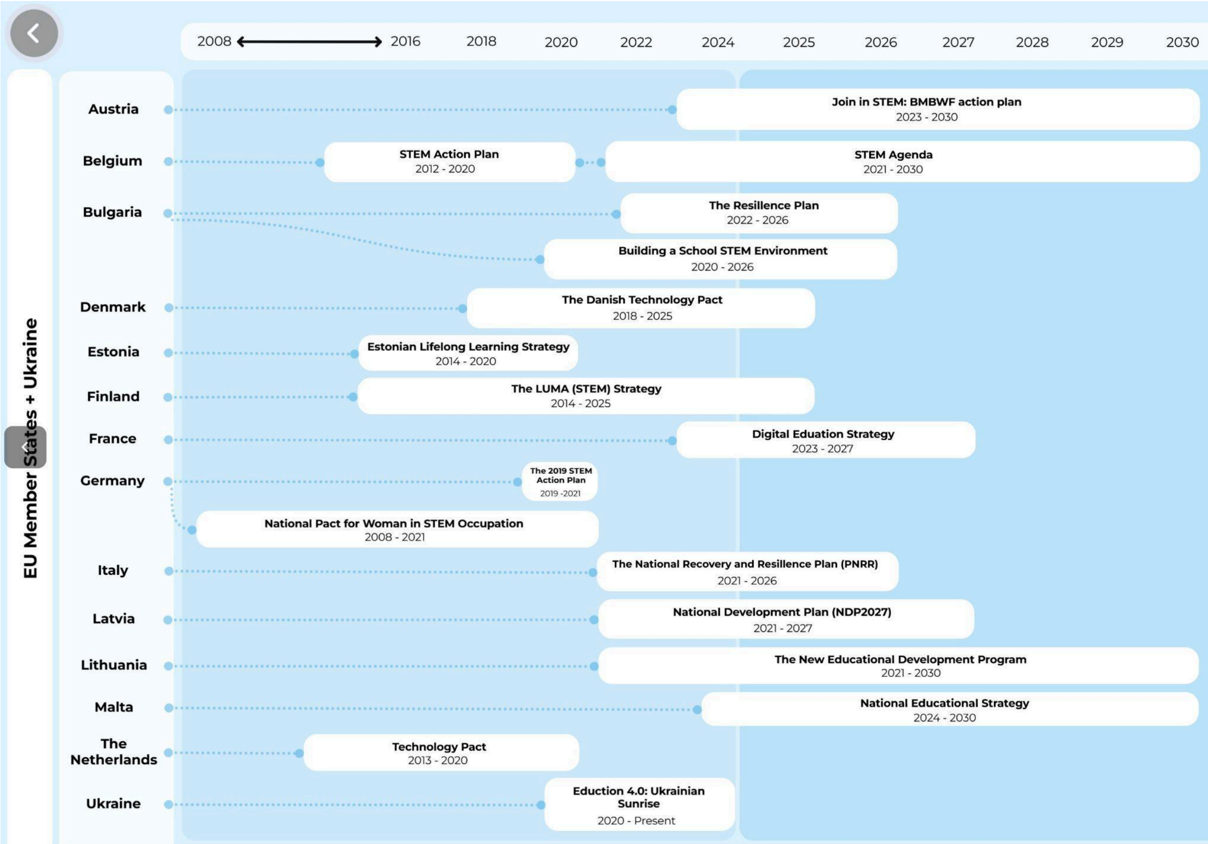


Figure 7: Timeline *of* STEAM plans in EU Member States.

The analysis of EU and Member States policies and gaps then fed into the development of policy recommendations, which have then been tested in a series of workshops documented in D3.3. These recommendations, which lay the foundations for the Road-STEAMer roadmap, are structured across four main themes, or policy areas, each with two recommendations with action points at local, national and regional (EU) levels.

1. Strengthening the STEAM Curriculum at National and EU Level
    - Redefine STEAM as a Holistic Curriculum
    - Develop STEAM Learning Materials and Teacher Resources
2. Enhancing the Learning Environment and Teacher Training
    - Prioritise STEAM Training for Educators
    - Foster Collaborative Learning Environments
3. Aligning STEAM with Societal and Industrial Needs
    - STEAM for Societal Impact

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- Encourage Partnerships with Industry

4. Promoting Equity, Diversity, and Inclusion in STEAM
   - Broaden the Scope of Inclusion Policies
   - Promote Intersectional Approaches in STEAM.

## 1.4. Current context of EU funding schemes on STEAM and education

One of the first steps towards developing the Road-STEAMer roadmap for science education under Horizon Europe has been to assess the extent to which European Commission funding currently supports STEAM (Science, Technology, Engineering, Arts, and Mathematics) initiatives. This roadmap aims to provide a strategic plan that will guide the EU's key funding program for research and innovation, helping to foster greater interest in STEM through the integration of artistic approaches, creative thinking, and applied arts (the "A" in STEAM).

To support this effort, WP5 partners have conducted research on current European Commission funding schemes that have supported STEAM-focused projects in recent years. Given that the focus of the roadmap is on Horizon Europe, the team analyzed calls for funding under this programme for the periods 2021-2022 and 2023-2025, specifically those aligned with the objectives of the *Road-STEAMer* project. Additionally, the Erasmus+ work programmes for the same time periods have also been subject of a separate analysis, given their relevance for schools across Europe.

To initiate this analysis, we identified key terms based on the Road-STEAMer research and deliverables from years 1 and 2, as well as collective brainstorming. The identified keywords included: STEM; STEAM; STE(A)M; Science education; Arts education; Open school; Creativ* (to cover a wider range of terms such as creativity, creativities, creatively, creativeness); Soft skills; Critical thinking; Equity; Interdisciplinarity; Transdisciplinarity; Living lab; Artistic; Mathematics; Science; Technology; Engineering; Digital education. The team then conducted a thorough search for the presence of these keywords across all relevant Horizon Europe and Erasmus+ work programmes and calls.

Although not initially considered as a central objective of the research on funding schemes supporting STEAM and STE(A)M education, recent developments in AI and insights from the

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workshops with stakeholders, have led project partners to explore the current funding available for Artificial Intelligence (AI) and how these can be relevant for STEAM projects to integrate AI into education, enhance digital skills, and promote ethical use of AI within STEAM frameworks. Details results of the analysis can be found in Appendix E.

### Analysis of results for Horizon Europe Work Programme and calls (2021-2022 and 2023-2025)

A high-level analysis indicates that certain Pillars within the Horizon Europe program fund proposals related to STEAM. Pillar II, “Global Challenges & European Industrial Competitiveness,” yielded the most relevant results. In contrast, STEAM-related keywords were not identified in Pillar III, “Innovative Europe.” Pillar I, “Excellent Science,” showed some potential, particularly in the Marie Skłodowska-Curie Actions and Research Infrastructures programs. The “Widening participation and spreading excellence” component of the “Widening participation and strengthening the European research area” program was also significant. In particular, the Road-STEAMer project has been funded under this program. Pillar II, “Global Challenges & European Industrial Competitiveness,” appears to be the primary source of funding for STEAM initiatives, specifically in Cluster 2 “Culture, Creativity and Inclusive Society,” Cluster 4 “Digital, Industry & Space,” and Cluster 6 “Food, Bioeconomy, Natural Resources, Agriculture & Environment.” Cluster 5 “Climate, Energy and Mobility”. We did not identify any matches for our keywords in Clusters 1 and 3.

In alignment with the established criteria, the most relevant results emphasized or at least included interdisciplinary approaches and the integration of science and technology with arts and creativity. Additionally, educational initiatives that bridged the scientific and artistic worlds, fostering cross-pollination of methodologies and thinking styles, were considered significant. Such initiatives extend beyond the simple addition of siloed STEM disciplines.

While the identified results are promising, there remains room for improvement in funding STEAM activities in their various facets. In many cases, where arts and sciences are mentioned, the focus on science and arts education for youth, future generations and current workforce is limited. Furthermore, STEAM activities are often framed as traditional STEM approaches with a superficial emphasis on the “A” to attract women to STEM/digital careers, rather than adopting a more comprehensive approach, as reccomanded by the Road-STEAMer research. Arts and cultural literacy, crucial for social inclusion and cohesion, to do seem well integrated into calls for technical topics.

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## Best practices and opportunities for further development

As part of the analysis of the Horizon Europe work programme, we identified some calls that not just include the relevant keywords in a relevant context, but which appear to encourage the development of STEAM educational practices in line with Road-STEAMer's criteria.

Aside from the call under which Road-STEAMer and its sister projects have been funded with the aim to create roadmaps for STEAM education (HORIZON-WIDERA-2021-ERA-01-70), which is clearly and openly about STEAM, there are other Horizon Europe calls that included research onr STEAM. These are presented below, together with comments on how they appear to embody Road-STEAMer's vision of holistic STEAM approaches.

**HORIZON-CL2-2021-TRANSFORMATIONS-01-05: Integration of emerging new technologies into education and training**. This call, which resulted in the funding of five projects (ExtenDT², Project EMPOWER, i-MASTER, e-diploma and Augmentor project), aims at producing research that supports the use of digital technologies in education, though research on how to use new technologies in learning environments, and on how to train and upskill teachers and educators (a key gap also according to Road-STEAMer's own research). This call explicitly required applicants to engage with both technology (including notably digital technologies) and innovative pedagogies, in order to foster critical thinking and creativity. A notable element is the focus on "how different learners experience and benefit, or are excluded from, digitally enhanced learning", which echoes Road-STEAMer's criterion of inclusion/personalisation/empowerment and underlying equity principle. Interestingly, examples of diversity are not limited to gender, but include factors such as migration background, disability and neurodiversity, among others (in line with D2.1). Collaboration is also present, both as a requirement of the proposals and as an expected outcome of innovative teaching practices. While other Road-STEAMer criteria (thinking-making-doing, disciplinary inter-relationships, real-world connections) are not explicitly encouraged, they remain attainable within the framework provided. Despite the absence of the very acronym "STEAM" (STEM is equally absent), this call is very well placed to promote educational best practices fully in line with a holistic view of STEAM.

**HORIZON-CL6-2021-COMMUNITIES-01-06**: **Inside and outside: educational innovation with nature-based solutions**. This call aims to promote innovative educational approaches that leverage nature-based solutions. This initiative extends beyond traditional classroom settings to encompass both formal and informal learning environments, including outdoor

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education. It encourages interdisciplinary collaboration between researchers from various fields, including STEM, social sciences, and humanities, to address real-world challenges through problem-based learning. It emphasizes the use of game-based learning strategies to engage students actively and promote collaborative problem-solving. By incorporating outdoor education and green learning environments, the call seeks to foster creativity, critical thinking, and problem-solving skills among primary and secondary school students. While the call emphasizes the importance of gender equality, it could benefit from a broader focus on inclusion and diversity to ensure that all learners have equal opportunities to participate and benefit from these innovative educational experiences.

**HORIZON-CL6-2021-COMMUNITIES-01-04: Socio-economic empowerment of the users of the sea**. The call encourages interdisciplinary collaboration among researchers from various fields, including STEAM disciplines, to address pressing challenges like climate change and human impact on coastal zones. By promoting citizen science, this call empowers individuals, particularly marginalised groups such as women and young people, to actively participate in research and decision-making processes. While the call emphasizes the empowerment of vulnerable groups, a clearer articulation of how this will be achieved is needed. The potential for tokenistic inclusion exists if concrete measures are not taken to ensure meaningful participation and impact. This approach seems to foster a sense of ownership and responsibility but also creates opportunities for skill development and job creation. While the call doesn't explicitly mention creativity, it recognizes the importance of innovative solutions and multi-actor approaches to achieve sustainable and equitable outcomes. While the call acknowledges the importance of STEAM disciplines, the specific role of arts and humanities in addressing coastal challenges remains unclear. A more explicit integration of these fields could lead to innovative and culturally sensitive approaches.

**HORIZON-MISS-2023-OCEAN-01-11: Ocean & water and arts: the contribution of creative sectors to Mission Ocean and waters.** The call emphasizes the crucial role of art and creativity in addressing pressing ocean and water challenges.By fostering interdisciplinary collaborations between artists and scientists, this initiative aims to raise public awareness about critical issues such as biodiversity loss, pollution, and invasive species. The call encourages creative and novel artistic expressions that can connect the public with the ocean in meaningful ways, fostering a deeper understanding and appreciation for these vital ecosystems. While the call does not explicitly mention formal education, it has the potential to significantly impact public perception and engagement with ocean-related

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issues, which can indirectly influence educational approaches and inspire future generations of ocean stewards. However, it's important to note that the specific criteria for project selection may not explicitly address all aspects of STEAM education, such as collaborative learning, personalized learning experiences, or the development of "thinking/making/doing" skills. The call funded two projects referring to arts in their titles, Participatory Art for society engagement with Ocean and Water, PartArt4OW, and TIDAL ArtS: TransformIng anD inspiring Aquatic Landscapes through Art and Sciences.

**HORIZON-WIDERA-2022-ERA-01-70**: Open schooling for science education and a learning continuum for all. The call aimed to promote creation of new partnerships that foster networking, sharing and applying science and technology research findings amongst teachers, researchers and professionals across different enterprises and thus to encourage science studies and science careers by supporting cross-community networks of stakeholders to address issues such as the Green Deal, Health and Digitalisation. The funded projects should encourage industry-funded innovation to become part of lifelong learning programmes and increase female participation in science studies and science careers and deconstruct gender stereotypes. The call funded three projects, of which two specifically on STEAM: STE(A)M Learning Ecologies, in addition to ICSE Science Factory (International Centre for STEM education Science Factory) and LEarning VEntuReS for Climate Justice. Specifically, the project STE(A)M learning ecologies (2023-2025, financed with 1.99 M€) is working in close collaboration with Road-STEAMer; at present it has produced the methodology of the STEAM learning ecologies. as well as the methodology to be used for the monitoring and the reflection of such ecologies.

**HORIZON-CL2-2023-HERITAGE-01-08**: Cultural and creative approaches for gender-responsive STEAM education. The call's expected outcomes include: (1) coordination network between organisations from the cultural and creative industries (CCIs), civil society, technological enterprises, secondary and higher education institutions and digital citizen platforms to foster the uptake of artistic, cultural and social science approaches in STEM education, research and innovation. (2) Increased understanding about the benefits of integrating artistic, cultural and social science approaches in STEM education, research and innovation and its impact on competitiveness, gender equality and career perspectives. (3) Pilot for the first European Union "STE(A)M week for future women innovators" engaging at least 4000 students in STEM educational activities through cultural and creative approaches. (4) STEAM skills development and increased interest in new technologies, including those

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applied to cultural value chains and cultural heritage, to bridge the gender gap.
The call funded one project: [STEAMBrace] (2024-2026 financed with 2.88 M€). This project aims to bridge the current gender gap in STEM fields by unlocking the potential of STEAM (STEM + Arts) education approach for future European innovators, especially women. Thus, this project will establish a coordination Alliance at European level and develop numerous networking and educational activities using creative thinking and a scientific evidence-based approach. This will lead to broad, sustainable (environmental-responsible, social-inclusive & economically-balanced) and inclusive (gender, geodemographic and socioeconomic wide-ranging) STEAM education methodology. Cultural and creative industries (CCIs) are drivers of the cultural and creative-driven innovation ecosystems, combined with validation with 11-18 years old students, that will allow to better understand the gaps and limitations of STEM education regarding country, age, gender and other socio-cultural aspects and boost the change towards a sustainable, reproducible & inclusive European STE(A)M education. The project will deliver a digital hub for participant networking (both students and stakeholders); missing information on STEAM level of implementation in Europe; numerous country-adapted training activities to boost integration of STEAM approaches in secondary and vocational training schools, with specific activities for young women and rural students.

HORIZON-WIDERA-2023-ERA-01-10 Support to the implementation of an EU Manifesto for STE(A)M education and research and innovation career paths to tackle gender inequalities in the ERA

The call funded one project: STREAM-IT "St(R)E(A)M It/Streaming Girls And Women Into Steam Education, Innovation And Research" (2024-26 financed with 1.85 M€). It aims to bridge persistent gender gaps in STEM education, research and innovation by implementing the European Manifesto for gender-inclusive STE(A)M education and careers. The call expected outcomes are: (1) Common principles and joint commitment on gender-inclusive STEAM education, research and innovation among a wide range of R&I actors in Member States and Associated Countries; (2) Network of STEM-oriented businesses, secondary and higher education institutions, research organisations, informal science education establishments, and civil society organisations, supporting knowledge sharing, mutual learning and structural change towards gender equality and diversity at their organisations; (3) Increased cooperation between relevant R&I actors from academia, the private sector, and national administrations to foster women and girls' participation in STEM studies and careers through a STEAM approach.

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**Horizon 2020 funded projects related to STEAM**

Through partners' knowledge, expert interviews, as well as by mapping the mapping SENSE and SEER projects' deliverables, we identified 9 projects related to STEAM financed by Horizon 2020 and Horizon Europe, mostly in pillar 2 but also Marie Skłodowska-Curie Actions:

- CREATIONS - Developing an Engaging Science Classroom, H2020-SEAC-2014-1 CSA that took place in 2015-2018 (1.979 M€)
- PERFORM - Participatory Engagement with Scientific and Technological Research through Performance, H2020-SEAC-2014-1 RIA that took place in 2015-2018 (1.997 M€)
- Marine Mammals - Using marine mammals for making science education and science careers attractive for young people, H2020-SEAC-2015-1 CSA that took place in 2016-2019 (1.797 M€)
- VERTIGO Adding socio-economic value to industry through the integration of artists in research and open innovation processes, H2020-ICT-2016-1 CSA that took place in 2016-2020 (4.258 M€)
- STORIES - Stories of Tomorrow - Students Visions on the Future of Space Exploration, H2020-ICT-2016-1 RIA that took place in 2017-2019 (2.703 M€)
- BLOOM Boosting European citizens knowledge and awareness of bioeconomy, H2020-BB-2017-1 CSA that took place in 2017-2020 (2.4 M€) - although not specific on STEM
- SALL Schools as Living Labs, H2020-SwafS-2019-2-two-stage CSA that took place in 2020-2023 (1.51 M€)
- OTTER - Outdoor Science Education for a Sustainable Future, H2020-SwafS-2020-2-two-stage CSA took place in 2021-2024 (1 59M€)
- REGGAE Researchers for European Green Growth And Education, Marie Skłodowska-Curie Actions MSCA-NIGHT-2020bis - European Researchers' Night , CSA that took place in 2021 (0.153 M€)

More in general, the analysis highlights that there are many calls and projects that enact the STEAM approach but are not labelled as such, and yet they could provide relevant educational material for secondary and tertiary education. Thus a recommendation for future calls in Horizon Europe and FP10 is to embed into calls the suggestions for projects to exploit citizen science and co-developing research with secondary and tertiary education, including vocational education, as well as co-producing learning material that is project based, for mutual benefits.

## Erasmus+ funded projects related to STEAM

**2021-2024 Work Program**

Given the relevance of the Erasmus+ programmes for the present and future of education, we have also researched for Erasmus+ Annual work programmes from 2021 to 2024 the relevance of the same key words and the taxonomy we have used as criteria for Horizon Europe. The identified keywords included: *STEM; STEAM; STEAM; Science education; Arts education; Open school; Creativ** (to cover a wider range of terms such as creativity, creativities, creatively, creativeness); *Soft skills; Critical thinking; Equity; Interdisciplinarity; Transdisciplinarity; Living lab; Artistic; Mathematics; Science; Technology; Engineering; Digital education.*

The most relevant results for Erasmus+ in the analysed time period have been found within **Key Action 2 – Cooperation among organisations and institutions**. The results of the research showed attention to promoting participation of women and girls in STEM fields as one of the key goals of Erasmus+ funding with reference to these disciplines. Indeed, Key Action 2 Priorities explicitly include "**Developing a STEAM approach in higher education, and foster women participation in STEM**". Whilst this is a positive objective, the Road-STEAMer project recommendations suggest that this approach should not be an end in itself and it should rely on the "A" of Arts as an instrumental tool to attract women, as this can prove to be based on stereotypes.

In the results between 2021 and 2024 we have also found an interesting relevance of funding and stimulating innovative teaching and learning approaches to tackle societal challenges, which resonated with the Road-STEAMer perspectives on STEAM being centered on real world challenges. Further outputs of the criteria we have applied to this research mentions the *"use of multidisciplinary pedagogies (teaching of science in political, environmental, socio-economic, and cultural contexts)"* as a "*powerful vehicle for making STEM subjects and careers more attractive."* Overall, our research shows that a more explicit attention to STEAM education should be present in calls for funding also within Erasmus+.

**Erasmus+ projects related to STEAM**

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Through a snowball technique (Streeton, Cooke & Campbell, 2004) we identified 10 relevant projects financed by Erasmus+ from 2012, from the knowledge of project partners as well as mapping SENSE and SEER projects' deliverables and co-design activities:

- **EU STEM Coalition** (2012-present): EU's main network of regional/national STEM platforms. IT fosters EU-wide cooperation between national STEM platforms.
- **EuroSTEAM** (2016-2019) aimed to provide accessible STEAM camps throughout Europe which teachers used in their classrooms to enhance the students experience of the STEAM subjects.
- **STEAM4SEN** (2019-2022) Inclusive and innovative STE(A)M education for students with special education needs
- **STE(A)M IT** (2019-2022) innovative and cross-disciplinary approaches to STEM (science, technology, engineering and mathematics) teaching.
  - **STEMonEDU** (2020-2022) aimed to increase the adoption and impact of STE(A)M education by investing in the community of stakeholders and the professional development of educators. Through co-design it developed the MOOC "Professional development of STE(A)M educators".
- **Choice** (2020-2022) aimed to promote and improve STEM education at schools by designing innovative Open Educational Resources (OERs) collected in a MOOC, policy reccomndations and teachers training resources
- **ATS STEM** (2020-2022) - Assessment of Transversal Skills in STEM was a policy experimentation project  conducted across 8 EU countries aiming to enhance digital assessment of second level students' transversal skills in STEM (Science, Technology, Engineering and Mathematics).
- **Learn STEM** (2021-23) Innovative Model of learning STEM in secondary schools. It aimed to product LEARN STEM Pedagogical Model, a definition of LEARN STEM Teacher Training Programme, the Design and test of the LEARN STEM online learning environment on the topics of: recycling, pollution, nature, climate.
- **SPICE** (2022-2025) comprises a bundle of actions aims to enhance Primary Education Teachers' ability to implement effective STEAM instruction for protecting students with Mild Disabilities (Special Education) from educational and social exclusion. STEAM is used both as the means and as the purpose for enabling a much-needed shift in Special Education in Primary Education both at an in-service and pre-service level.

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- **Girls self-ESTEAM** (2023-2025) Empowering girls through digital and entrepreneurial competencies to follow a career in ESTEAM

Other initiatives to promote STEAM funded by the EU but not through Horizon or Erasmus+ include:

- **ESTEAM Fests** (2022-24) organized by European Innovation Council and SMEs Executive Agency (EISMEA), ESTEAM stands for Entrepreneurship, Science, Technology, Engineering, Arts and Mathematics. Over the three years of the project, STEAM events are  organised in 19 EU Member States with the aim to boost women and girls' competences, inspire them, and give them the chance to connect with like-minded peers. An interactive map with the previously EU funded projects on STEAM is provided within the roadmap, by clicking on the "previously funded projects" box (Figure 8).

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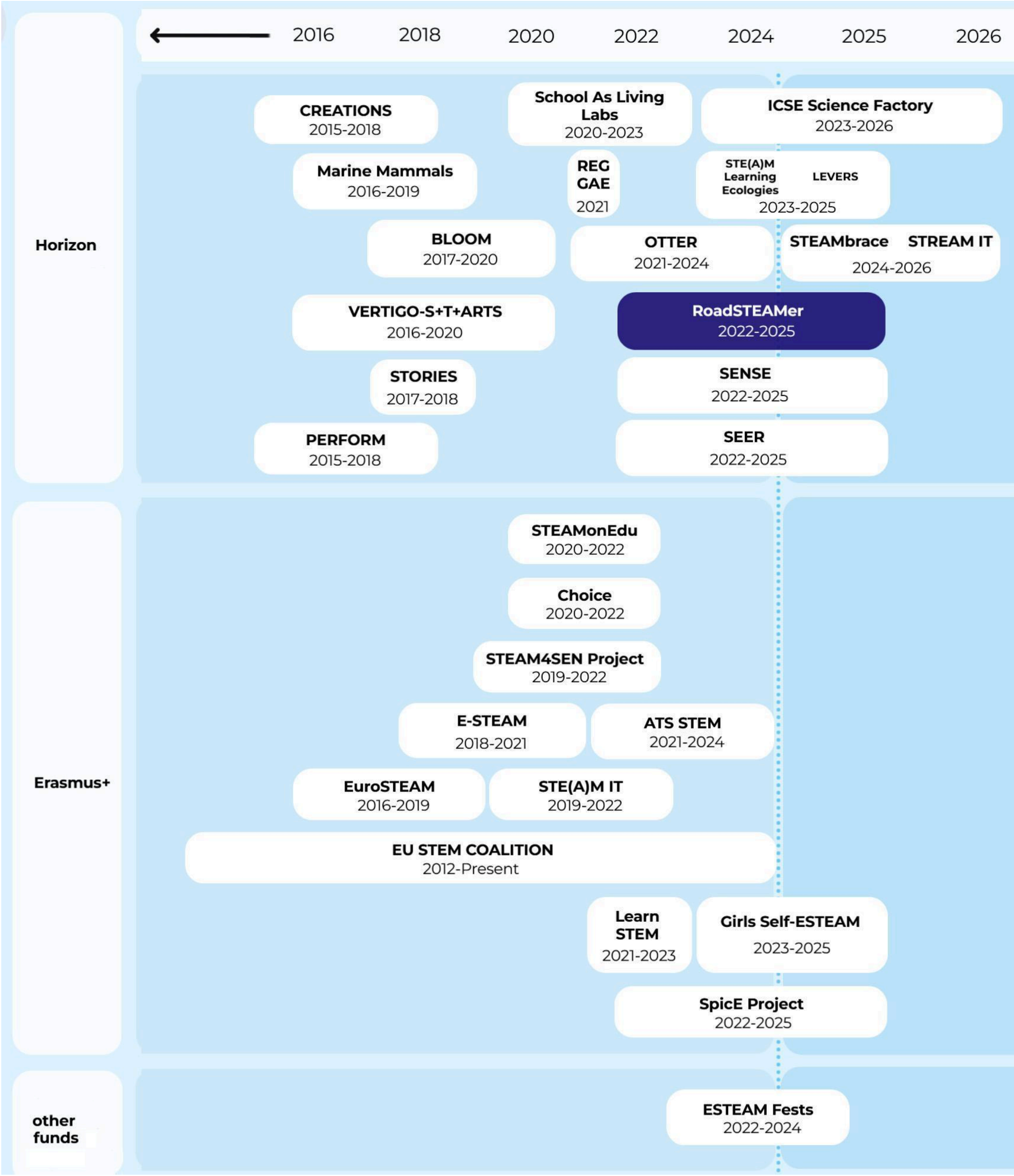


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*Figure 8. Previously EU funded calls and projects (interactive graph page 2)*

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## 1.5. Co-design workshops with stakeholders on foresight of industry needs, career paths and inclusive education in 2035

To be able to provide relevant policy recommendations for the upcoming research framework agreement (FP10) of the EC, the time frame considered is 2035, as the next Framework Programme agreement is envisioned to run from 2028 to 2034. Foresight of ten years is a demanding and challenging activity due to the complexity of the current world scenario. Yet, forecasting industry needs in STEAM and potential changes in the field of education due to technological advancements such as Artificial Intelligence (AI) and the revised EU priorities, is a necessary step for developing future-proof policy recommendations. A series of 14 co-design workshops and 4 individual dialogues are conducted with relevant STEAM stakeholders, including industrial players, students with diverse needs or disabilities, educators, special needs educators, parents, school and university heads, as well as policy makers for a total of 79 participants. The methodology adopted is based on the widely utilized technology roadmapping (Phaal et al. 2004) developed at the University of Cambridge and extended to facilitate massive co-design (Meroni, Selloni & Rossi, 2018). The most notable feature of the technology roadmapping technique is its ability to visualize processes, which is particularly effective in enhancing the efficiency of co-design efforts (Bresciani, 2019) and could thus support massive codesign in policy-making (Meroni et al., 2018). We develop and apply a progressively pre-filled visual canvas for co-design with stakeholders based on collective intelligence, capture through progressively pre-filled visual roadmapping canvas (Bresciani, Jiang  & Rizzo, 2025; and explained in more details in the Appendix A).

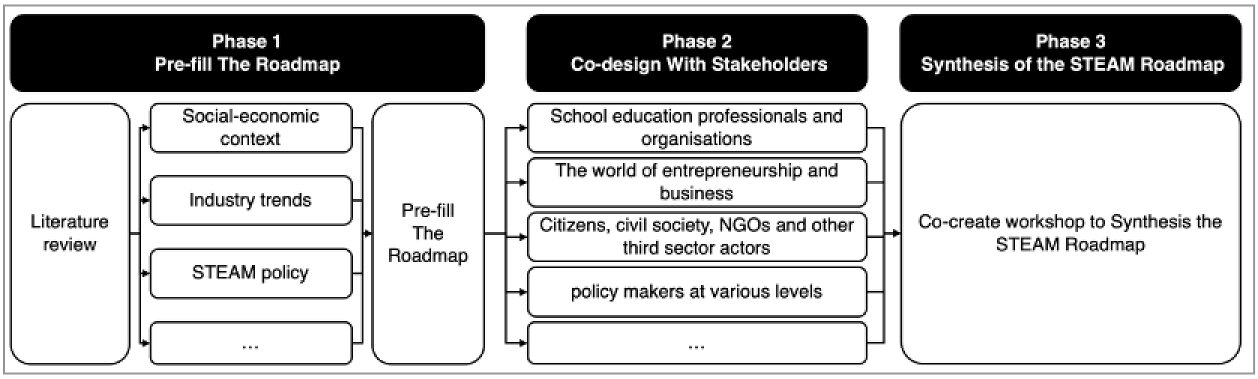


Figure 9: *The policy roadmapping massive co-design* methodology *developed and deployed in this project*

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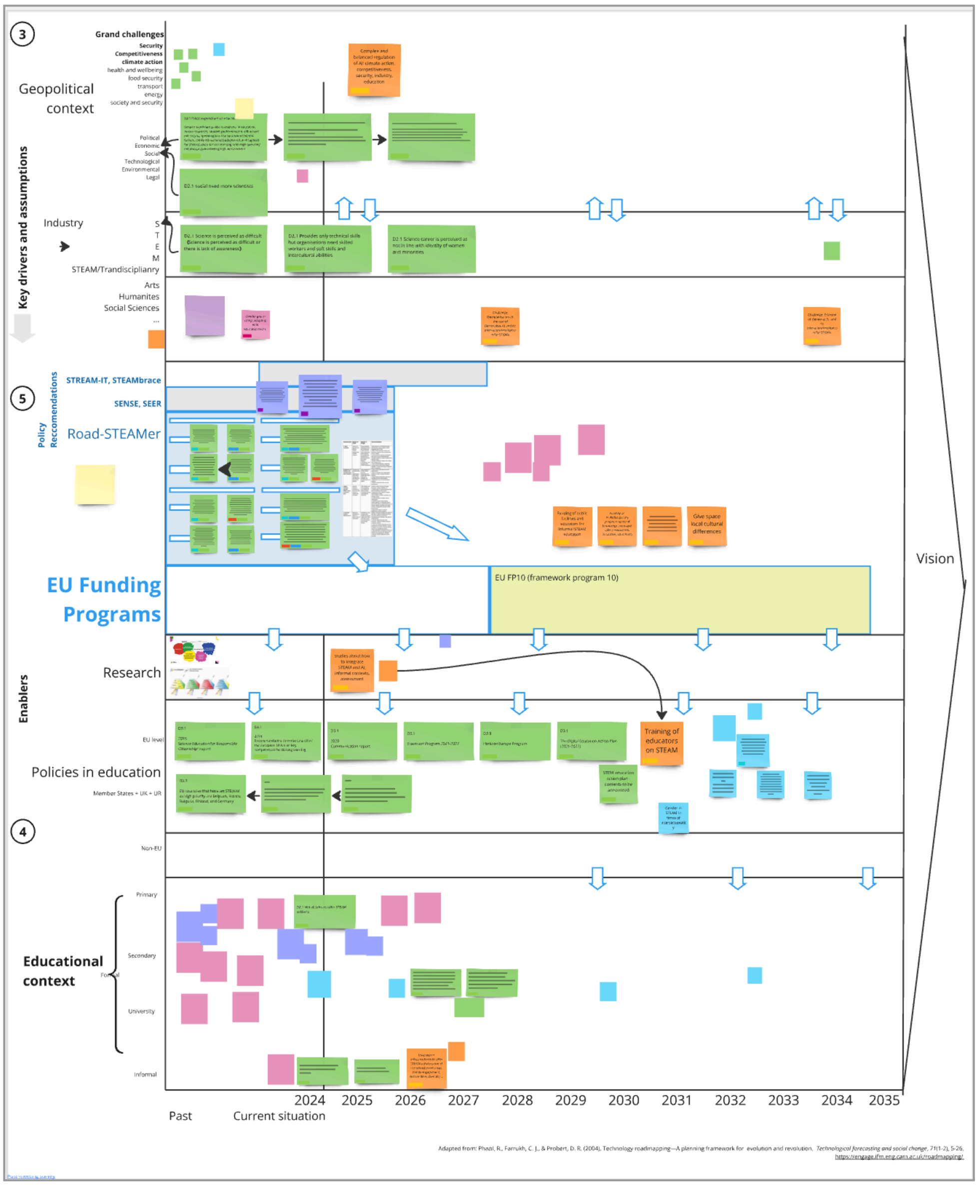


Figure 10: Illustrative example of one of the foresight co-design workshops outcome, facilitated with a pre-filled roadmapping canvas.

The methodology is structured into subsequent co-design steps, as illustrated in Figure 8. The Canvas (Phaal et al., 2004; Phaal & Muller, 2009) has been adapted to STEAM education policy making and is pre-filled with information from the project deliverables, in particular the socio-economic context (D2.1) and existing policies at EU and Member States (D3.1). This pre-filling provides participants with a synthesis of evidence-based information on which to base the co-design foresight activity and related policy proposals. Multiple co-design workshops have been organized: the contributions provided by participants are visually synthesized in the canvas for the next phases, resulting in a progressively pre-filled roadmapping canvas, including a workshop with 4 EU funded projects on STEAM: SEER,

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SENSE, STREAM-IT and STEAM-BRACE. An example of the outcome of a workshop is provided in Figure 9.

### Synthesis of foresight co-design workshops results

After gathering policy suggestions from a series of co-design workshops with all relevant stakeholders, the input of all workshops are aggregated on a single canvas. Input (in the form of post-its) are visually re-grouped according to thematic areas and timeframe (as the canvas is a timeline), a synthesis to consolidate the inputs into policy proposals for testing with policymakers. Details regarding workshop participants are provided in the appendix.

#### Meta level: naming STEAM

From a meta perspective, the issue of the naming and definition has emerged strongly, with subjects of different nationalities not being familiar with “STEAM” and sometimes not even with “STEM”. When familiar with the acronyms, the understanding was mostly narrowly perceived to a single technical or scientific discipline, not understanding what the “arts” could provide and being reluctant to such topics. Stakeholders (including lecturers and program managers) knowledge does not seem to reflect the developments of the current academic debate.

#### Coherent STEAM education policies and strategies at EU and national level

Results show stakeholders’ interest in a transnational definition of STEAM education (and eventually of STEAM schools) at EU level. It is recommended that the EU suggests Member States adopt the unified STEAM policy and strategy at national level.

#### Making an economic case for STEAM education

To support the EU and Member States in defining and adopting a unified STEAM education strategy adaptable to be able to respond to national challenges, it is suggested to fund research projects to make an economic case for STEAM and interdisciplinary education to replace or heavily revise traditional national education paradigms: interdisciplinary skills-based (rather than knowledge-based) educations, focused on real word challenges, could provide several economic benefits to European nations, off-setting the cost of a systemic change to the EU educational system. Research should be funded to test (i.e., with experimental trials) a variety of STEAM and transdisciplinary (existing or new) learning approaches and evaluate which approach is most effective for which type of learner, including learners with disabilities or belonging to vulnerable groups (incl. intersectionality).

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## Systemic change of the educational system and assessment: AI and inclusivity

The next decade (2025-2035) is expected to exacerbate the current disconnect between the knowledge-focused school system and the skills needed to address societal challenges (i.e., sustainability, competitiveness and security), industry needs (i.e., of technologically literate but also socially competent workforce) and personal development (i.e., the mental health emergency and continuous learning). A systemic reform of the educational field is required, with nations needing to allow more flexibility in the national curricula of secondary education beyond and timetables, and more flexibility for teachers and tertiary education lecturers to work together on cross-disciplinary projects, for the development of their own skills in STEAM education, adaptation of learning material and best practices for real-life challenges, career simulation, and students' skills development.

In the era of Artificial Intelligence (AI), beyond a strong basis of basic reading, writing and mathematics, education should focus on developing skills (such as critical thinking, communication, collaboration, etc.) rather than knowledge. Assessment has to change accordingly. AI does not only affect the type of knowledge and abilities needed by the future workforce, but provides the opportunity for a fundamental innovation in the educational sector, providing the opportunity for personalized learning that humans have never experienced in history. As traditional class teaching and even tutoring and corrections of assignment can be delegated to AI, lecturers have to be retrained to focus on harnessing the possibilities of AI in education and focus on providing value to learners by focusing on tasks that AI cannot perform. Research funds should be provided to experiment and test the effectiveness of novel teaching approaches that include life skills (such as the EU LifeComp), in relation to career exploration, as well as teachers' training.

More research is needed to optimize the use of AI for the different educational levels, and to explore the opportunities of technology for providing more flexible and inclusive education opportunities for vulnerable groups and learners with diverse abilities.

## Multi-stakeholder collaborations through open-schooling

Participants highlighted the need for the educational system at all levels to better ground teaching to societal and industry needs through collaborations with profit, civic and governmental organizations, such as with the open school approach and participation in living labs. For these reasons, the EU and national governments should provide coherent policies to facilitate organizations (companies, governmental, civic and non-profit

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organizations) to work together such as by sharing or sponsoring spaces and equipment, or by offering joint diplomas and degrees (i.e., companies with credited secondary education institutes and universities)

### Develop and test STEAM and interdisciplinary learning material and educators training

Teachers, lecturers and program managers highlighted the need to have the time (beyond their free private time) during working hours to learn about STEAM approaches, and to easily find and adapt STEM learning material in their own language, and to have evidence of the pedagogical efficacy of such STEAM and interdisciplinary learning material that is based on real-life challenges and skills development, according for example to the EU "Lifecomp" and related to a range of careers exploration (in collaboration with external stakeholders including companies and governmental organizations). Such material should be available in national languages and systematized in a one-stop-shop digital space where lecturers can easily find materials in EU languages, share and have peer-to-peer support, differentiated into pre-service and in-service.

### Life and career design along the learning continuum

The choice of pursuing secondary or tertiary education in a STEAM discipline -or not- seems not to be based on solid and realistic understanding of the actual lived experience and career implications. Improvements can be made to better support learners along the learning continuum, from primary school to retirement, to understand more concretely what it entails to take a STEAM-related course of studies and career. EU funding could be directed toward the better communication of benefits and exploration of careers in high demand and in relation to EU priorities (i.e., the Green Deal, security but also entrepreneurship); longitudinal studies should be funded to develop and test life and career design support (i.e., structured activities between secondary and tertiary education, or teachers/university lecturers training on career design support to students).

## 1.6. Integrating and synthesizing all information in a roadmap

All the information and knowledge developed in the project and synthesised in the preceding sections of this deliverable had to be integrated to develop the roadmap. Based on a benchmark of relevant roadmaps, the project roadmap has been developed in the format of a matrix with columns as priority areas and rows as funding instruments. Each "cell" of the matrix is further detailed into two time frames: the current funding program until 2027 and the

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next FP10 from 2028 to 2034. On such matrix all information has been mapped: policy recommendations (D3.3), emergent themes from the co-design foresight workshops (Section 1.6), input and recommendations from projects funded under the same call SEER and SENSE, scientific evidence, previously funded projects and other examples, and EU priorities. Two further workshops have been conducted within the consortium and with EU funding experts to align the mapping of all the information and define the priority areas (which are an evolution of the policy recommendation in D3.3 based on further input). More details are provided in the appendix and in Bresciani & Rizzo (2025). Several key challenges were identified in the effort to advance STEAM education, align policies with Horizon Europe, and ensure an inclusive, interdisciplinary approach. These challenges covered funding, policy alignment, inclusivity, and the role of emerging technologies in education and provide the basis to define the actions of the roadmap outlined in the next Chapter.

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# 2. A roadmap for STEAM education

## 2.1. Visual overview

With the aim to provide a concrete plan of action for STEAM education in EU funding programs, recommendations are organized into four key priority areas, detailed into potential funding and policy instruments, including in particular Horizon Europe (but also Erasmus+), forming a matrix of actions.The timeframe is established according to the two programs, Horizon Europe from present until-2027 and the European Commission Framework Program 10 that will take place in 2028-2034. A visual synthesis of the roadmap is provided in Figure 10: details for each action are outlined in the online [interactive roadmap] as well as in the next Section 2.2. For each action, a brief description, examples and references are provided, as well as the relationship with the STEM Education Strategic Plan 2025.

Figure 10 provides the first version of the roadmap: the purpose of this first version is to collect feedback and further for further improvement, which will be included in D5.2 (roadmap version 2).

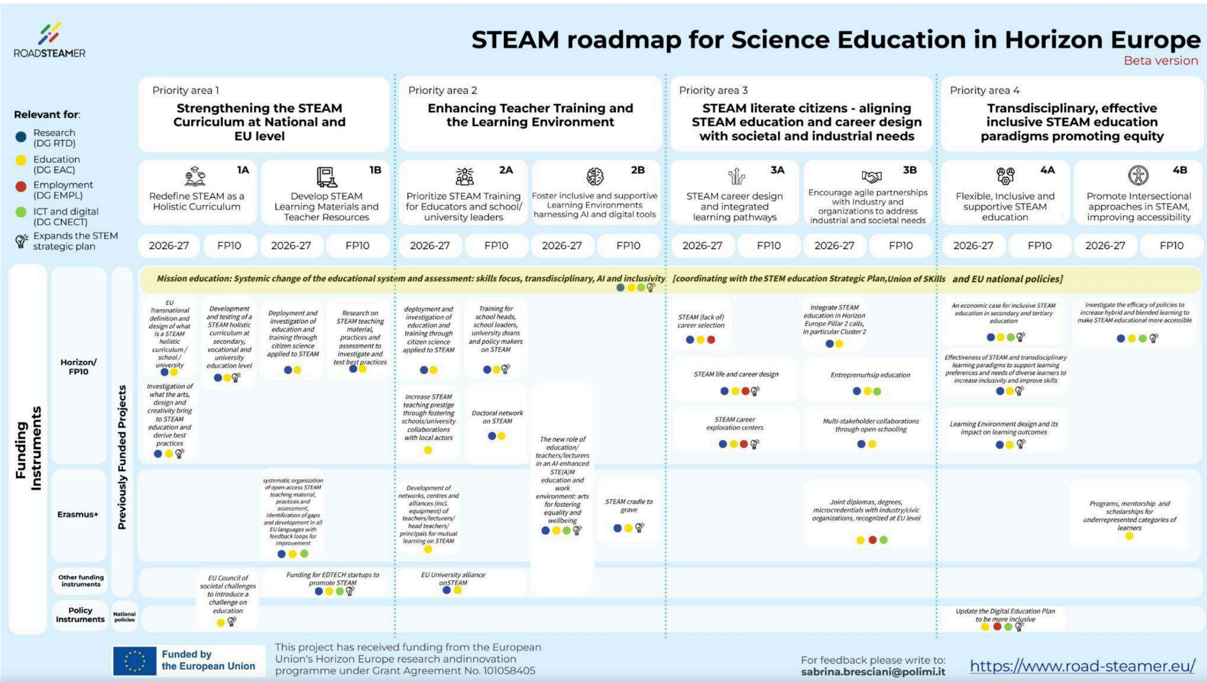


Figure 11: Image of the visual [interactive roadmap]

The roadmap is structured in 4 priority areas:

### Priority Area 1: Strengthening the STEAM Curriculum at National and EU level

1a) Redefine STEAM as a Holistic Curriculum

1b) Develop STEAM Learning Materials and Teacher Resources

### Priority Area 2: Enhancing Teacher Training and the Learning Environment

2a) Prioritize STEAM Training for Educators

2b) Foster inclusive and supportive Learning Environments harnessing AI and digital tools

### Priority Area 3: STEAM literate citizens - aligning STEAM education and career design with societal and industrial needs

3a) STEAM career design and integrated learning pathways

3b) Encourage agile partnerships with Industry and organizations to address industrial and societal needs

### Priority Area 4: Transdisciplinary, effective inclusive STEAM education paradigms promoting equity

4a) Flexible, inclusive and supportive STEAM education

4b) Promote intersectional approaches in STEAM, improving accessibility

To achieve the strategic goals outlined in the 4 priority areas, actions are mapped according to **key EU funding instruments**. Specifically, the core focused has been placed on Horizon Europe (Pillar 1,2,3, Widera) as outlined in the Road-STEAMer Grant Agreement, and yet other related funding programs have been considered for coordinated complementary actions, in particular the Erasmus+ program, which -to date- has financed a large number of STEAM projects.

**a) Horizon Europe (Pillar 1, 2, 3):** The primary EU research and innovation framework, Horizon Europe supports large-scale STEAM education projects that foster technological advancements, research initiatives, and policy recommendations. It is crucial for funding interdisciplinary research and educational projects that align with broader EU goals.

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**Pillar 1** consists of the European Research Council, Marie Sklodowska Curie Actions, and Research Infrastructures. **Pillar 2** consists of 6 clusters as follows: Cluster 1: Health Cluster 2: Culture, Creativity and Inclusive Society Cluster 3: Civil Security for Society Cluster 4: Digital, Industry and Space Cluster 5: Climate, Energy and Mobility Cluster 6: Food, Bioeconomy, Natural Resources, Agriculture and Environment. **Pillar 3** consists of the European Institute of Innovation and Technology (EIT), and Knowledge and Innovation Communities (KICs) between 2021 and 2027, which have the objective of creating systems of education, industries, networks, etc. They are institutionalized partnerships to animate specific ecosystems. WIDERA (Widening Participation and Strengthening the European Research Area) supports the inclusion of Eastern Europe and other instruments like Innovative Training Networks.

**b) Erasmus+:** A program primarily focused on mobility and cooperation, Erasmus+ plays a key role in facilitating transnational partnerships between educational institutions, promoting STEAM teacher training, and supporting the innovation of curricula and educational practices across Europe.

**c) National and Local Grants:** Various EU Member States offer funding programs that focus on integrating STEAM education into national curricula, modernizing learning infrastructures, and promoting educational equity and inclusion at local levels. These grants are often tailored to address specific national or regional needs.

**d) Other EU and Private Initiatives:** Additional funding sources come from digital education grants, social inclusion programs, and private-sector collaborations like the Digital Education Action Plan (2021-2027), The Digital Europe Programme, and the European Universities Initiative. These initiatives aim to enhance the connection between education and the labour market by supporting industry-led STEAM partnerships, as well as providing financial support for inclusive and accessible educational opportunities Each funding instrument is strategically aligned with specific priority areas in the matrix, ensuring that financial resources are directed where they will have the greatest impact in advancing STEAM education across Europe.

- **Policies infrastructure:** The section of policies has been divided into 3 major sections, having European, National, and Local levels (Schools/Colleges).
- **Infrastructures and other instruments** like The European Council for Societal Challenges, EU agency for artificial intelligence, New ERA European research area agenda 2027-2030, and others.

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- **Organizational meta-recommendations:** Efficiency of EU-funded projects and others.
- **Outcomes and impacts** consisted of the Strategic agenda 2024-2029 promoting three key components: A free and democratic Europe, A strong and secure Europe, and A prosperous and competitive Europe.

## 2.2. Specific recommendations for funding by priority area

According to the structure outlined, 30 specific actions are described in detail, providing an overview, suggestions for a timeframe and for funding instruments, examples (with links) to successful practices or projects, evidence from Road-STEAMer deliverables, evidence emerged from deliverables of the projects SEER and SENSE funded under the same call, evidence from scientific literature as well as the relation to the STEM Education Strategic Plan. Such sub-section is written in order to connect to and offer developments to the EC STEM education strategy, indicating if the action supports or expands the plan (by providing novel input not foreseen in the STEM Education strategic document. Within Road-STEAMer, our understanding of STEAM is grounded in a recognised need for transdisciplinary education and real world problem solving to address the global challenges that we face. With our focus on the Arts as well as STEM we extend and articulate the benefits of the relationship between STEM, the Arts, creativity, engagement, transdisciplinarity, and the creative industries which are currently touched upon in the strategy document.

While several projects on STEM and STEAM have been deployed throught the years, as outlines above, and a relevant body of resources is developed, the systemic barriers of national education systems, assessments and teachers time prevent effective and inclusive STEM and STEAM education to scale to a whole school approach. The core recommendation is to fund a long-term research project in the form of a “Mission”, with a similar structure to the currently funded EU Missions (Horizon Europe Pillar 2, Missions cities, adaptation, soil, ocean and cancer) as theorized and proposed by Mazzuccato (Mazzucato, 2011; 2018; 2021)

🔵Systemic *Action:* “Mission Education” - Systemic change of the educational system and assessment through coordinating STEM/STEAM education research actions for enhancing EU competitiveness through skills development, a harnessing AI and digital technologies for a transdisciplinary inclusive approach to learning

***Description:*** develop Mission for the systemic change of EU education to orchestrate systemic innovation for transdisciplinary inclusive technical education in the EU to inform and work in close coordination with the upcoming “European STEM executive Panel” and the European skills high level board (STEM Education Strategic Plan pg. 8) to enact the STEM Education Strategic Plan’s goal of “Improve overall STEM skills intelligence based on international indicators and benchmarks, by measuring graduate outcomes in VET and tertiary education” (pg.8). Such long-term project (or rather, program) should overcome the “fragmentation of resources across programs” (pg. 12), coordinating research, deployment and testing the use of digital educatio and AI in all educational levels, to boost the opportunities that it provides for flexible (hybrid, blended, online) and inclusive (customized) skills-based education opportunities for vulnerable groups and learners with diverse abilities. It will have a structure as the EU Missions (cities, adaptation, soil, ocean and cancer), mobilizing systemic change through long-term (7-10 years) coordination of actions within and between Euopean countries (as the National platforms in the Mission “Cities” and the “deep dives” of the Mission “adaptation”) to deploy and investigate the role of project-based, transdisciplinary, AI-enhanced transdisciplinary (challenge-based or phenomenon-based) education in supporting EU priorities. The Mission Education should coordinate the definition of process and outcome indicators, collecting data and monitoring STEM and STEAM practices, programs, schools and universities in the EU to inform policy making for evidence-based educational reforms.

***Potential funding instrument:*** Horizon Europe Pillar 2, Missions

***Suggested time frame***: 2026-27 + FP10 (7 to 10 years)

***Alignment with STEM Education Strategic Plan 2025***: This action expands the STEM Strategic Plan to orchestrate a systemic innovation in EU education, supporting the Union of Skills, to support the EU in achieving the goal of Improve overall STEM skills intelligence based on international indicators and benchmarks (pg.8).

The next actions are detailed by priority areas and should be coordinated by the “Mission Education” action, providing data to the coordinating action outlined above, while the Mission provides the orchestration of the actions, joint events and regular co-creation activities (such as the “deep dives” of the Mission Adaptation) to ensure alignment between projects.

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Actions are provided by priority area and color coded according to the topic of relevance and related EC DG:

🔵 DG RTD - Research *(blue)*
🟡 DG EAC - Education *(yellow)*
🟢 DG CNECT - Communications Networks and Technology *(green)*
🔴 DG EMPL - Employment *(red)*
💡 Indicates that the action provides an innovation that expands the EU STEM Education Strategic Plan *(light bulb)*

## Priority Area 1: Strengthening the STEAM Curriculum at National and EU level

### ***Theme 1a) Redefine STEAM as a Holistic Curriculum in EU***

🔵🟡 Action: EU Transnational definition and design of what is a STEAM holistic curriculum / school / university

***Description:*** from existing cases and scientific evidence of STEAM holistic curriculum and STEAM schools and universities, derive a pan-European definition and model that aligned with EU priorities (including digital education) and can be adaptable to national educational systems, identifying gaps and overlaps across EU MS and their alignment with EU priorities. Defining indicators, collecting data and monitoring

***Example of best practices***:

- STEM School label: A STEM School is defined as a school with a clear STEM strategy, characterised by different key elements and criteria. This definition is the result of the European STEM Schools Report which builds upon a vast literature review and a thorough consultation process with four groups of key stakeholders in Science, Technology, Engineering and Mathematics (STEM) education. Those key stakeholders are schools, STEM teachers, Ministries of Education and STEM Industries. The report's criteria for "STEM Schools" identify key areas that can help schools advance and have a clearer strategy for STEM education (funded by the H2020 project Scientix 4 Grant agreement N. 101000063, coordinated by European Schoolnet EUN)
- Penryn College: ***STEAM curriculum embedded in an arts/science college*** in which the learner's journey is mapped through various stages ensuring character build and career build are developed simultaneously through each step.

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- Nansledan School: This is a STEAM-based **program**, an experiential learning approach that fosters curiosity, resilience, and leadership, ensuring students build knowledge progressively and develop essential life skills.
- Centre for Research in Transdisciplinary Education This new Centre (est 2025) offers fertile dialogic ground to breed innovative ideas in educational research within and between subject disciplines. It draws on, and develops, new methodologies from arts-based, creative and post-qualitative methods through to exploratory quantitative approaches, working with STEAM and transdisciplinary educational practice and researching with community and industry partners.

***Potential funding instrument:*** *Horizon Europe, Pillar 2, Cluster 2 “Culture, Creativity and inclusive society”, destination “innovative research on social and economic transformation”*

***Suggested time frame***: 2026-2027
***Alignment with STEM Education Strategic Plan 2025***: This action aligns and enhances the plan for a pan-European STEM competence framework, including holistic curricula design for STEM skill competencies. This will also add an inclusive lens to assess STEM skills ( 3.2, pg. 9 "Developing by 2026 a STEM competence framework for all learners at all stages of education and a taxonomy of STEM skills within the ESCO classification. This will inspire and promote curriculum design, and assessment frameworks for STEM skills")

***Related policy recommendations: Road-STEAMer Recommendation 1 (D3.3), SEER D7.2***

***Evidence:*** Road-STEAMer-D2.3, Watts, D. S. and Richardson, J. W. (2020), SEER D7.2, Road-STEAMer D3.2

🔵🟡💡*Action:* Investigation of what the arts, design and creativity bring to STEAM education and derive best practices

***Description:*** Triangulate literature with bottom-up evidence of which contribution and under which conditions the arts and design bring effective benefits to STEAM education, including mental health and career readiness, in order and derive best practices of interdisciplinary and transdisciplinary education along the educational continuum (primary school to lifelong learning) within the European context.

***Example of best practices***:

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- Cultural Learning Alliance Project Is an activity, where Eastbourne's STEAM project used art and science to explore plastic pollution through photography, sculpture, journaling, graphic design, and culminating in a public exhibition.
- Creation features: SciArtsEdu is a **program** that blends science with creative arts like visual storytelling, music, and performance to make STEM education more engaging, accessible, and interdisciplinary. It also features "Teacher guides" that give a comprehensive overview on planning the STEAM curriculum based on pedagogy.
- Other examples: Particle Physics and the visual arts.

***Potential funding instrument:*** Horizon, Pillar 2 and WIDERA

***Suggested time frame***: 2026-2027

***Alignment with STEM Education Strategic Plan 2025***: This action supports and expands the plan advocating a stronger focus on the STE**A**M approach that supports holistic learning, curriculum design, that can be applied to create "Joint transnational programmes and short courses" in a more informed STE**A**M approach. (3.2, pg. 10 "Develop joint transnational programmes and short courses leading to microcredentials in strategic STEM sectors, as identified in the Competitiveness Compass, through the Centres of Vocational Excellence and European Universities alliances. In close cooperation with their respective innovation ecosystems and with EU skills academies: i) boost the available range of joint programmes and microcredentials in STEM, including with a STE**A**M (science, technology, engineering, arts, and mathematics) educational approach)

***Related policy recommendations:***

***Evidence:*** SENSE D3.2, Road-STEAMer D3.1, Road-STEAMer D2.2, Penprase, B.E. (2018), Pirrie, A. (2019)

🔵🟡💡*Action:* Development and testing of a STEAM holistic curriculum at secondary, vocational and university education level

***Description:*** Development and deployment of a variety of options for a STEAM holistic curriculum to be tested in longitudinal large scale control trials to derive evidence to inform policy decisions (Banerjee & Duflo, 2009), taking into account the STEAM criteria (Collaboration, Disciplinary inter-relationships, Thinking-making-doing, Creativity, Real-world connection, and Inclusion / Personalisation / Empowerment) and EU priorities (focus on skills-based education, digital skills, industry relations, etc.). To investigate intersectionality, studies should investigate the effectiveness of STEAM programs by variables of vulnerability

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(gender, country, disability, special learning needs, family background, family support, etc.), and teachers/lecturer ability.

***Example of best practices:***

- H-Farm: a secondary education **teaching program** based on the holistic International Bacchlaurate curriculum expanded to include STEM in collaboration with the Italian Institute of Technology (IIT), integrates science, research, and innovation, fostering interdisciplinary learning and technological advancements in education and cultural heritage.
- IB Silicon Valley: The holistic International Bacchlaurate curriculum Middle Years **Programme** (MYP) is enhanced with arts curriculum to encourage students to engage in both visual and performing arts, fostering interdisciplinary connections between artistic expression and STEM subjects. Through inquiry-based learning, students develop skills in creativity, communication, and innovation, essential for STEAM education.
- Other examples: International Baccalaureate transdisciplinary program, IB in public schools

***Potential funding instrument:*** Horizon, Pillar 2 and WIDERA

***Suggested time frame***: after action “Transnational definition and design of what is a STEAM holistic curriculum and school”; FP10

***Alignment with STEM Education Strategic Plan 2025***: The action expands the scope providing indications for conducting extensive research on the assessment of actions to inform policy making (3.2 pg. 8, In 2025, set up a European STEM Executive Panel at top business/political/administrative level to advise on strategic issues including curriculum modernisation, industry feedback on skills needs across industrial sectors, innovative teaching and content, and embedding academic-business cooperation in STEM education. The STEM Panel would provide actionable recommendations to foster close cooperation between business and STEM education to the European Skills High Level Board and make the results of its work publicly available to any other interested party.)

***Related policy recommendations: Road-STEAMer recommendation 1, D3.3, SENSE recommendation 1***

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***Evidences:*** Road-STEAMer D2.3, SENSE D4.4, SEER D3.2, JRC et al 2024; Banerjee & Duflo, 2009

🟡💡*Action:* EU Council of societal challenges to introduce a challenge on education

***Description:*** EU Council of societal challenges is advised to introduce a challenge on education and/or embed transversally education in all challenges, i.e., transdisciplinary STEAM approaches to support the climate emergency and STEAM focus on arts and skills-based open schooling approach to support mental health.

We advocate for the stronger integration of education—particularly school education, teacher training, and early tertiary education—into the European research and innovation (R&I) agenda, in response to the Expert Group's *Align, Act, Accelerate* Recommendation 7. This is an opportunity to enhance the existing collaborative framework between universities, research institutions, governments, civil society, and industry by explicitly recognising education as a driver of innovation, resilience, and societal transformation. Emphasising methodologies such as Open Schooling, STEAM education, Living Labs, Co-design, and Informal and Non-formal Learning, we call for dedicated funding, governance inclusion, support for transdisciplinary ecosystems, and investment in teacher capacity. Education is positioned not merely as preparatory but as an active co-creator of knowledge-based, human-centred solutions to complex societal challenges, contributing to a more inclusive, sustainable, and secure European future.

***Example of best practices:***

- **Schools as Living Labs***:* Living Lab is an open-innovation methodology where actors participate horizontally in an innovation process to co-create (STEAM-based) solutions to real problems. In education, living labs are places where students, schools, citizens, and organisations come together to co-create (ideas and tools). Living labs are ideal in addressing both hard and soft skills and greatly enrich the delivery of national curricula. The SALL initiative tested the Living Lab approach. 77% of teachers found that the SALL approach stimulates students' independence and problem-solving abilities. 78% found that the SALL approach enhances professional development in regard to project-based learning and open schooling (project results in Cordis). The project engaged 400+ schools.
- **Make it Open** empowered schools to act as drivers of community well-being by building synergies between educational institutions, enterprises, and civil society

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organisations. The project facilitated the co-design and implementation of activities in which students addressed real-life local challenges in partnership with their communities. Drawing on tools and methodologies from the maker movement, the initiative promoted hands-on, inquiry-based learning while strengthening schools' roles as hubs of social innovation and local engagement.

***Potential funding instrument:*** EU council of societal challenges

***Suggested time frame***: FP10

***Alignment with STEM Education Strategic Plan 2025***:

***Related policy recommendations:*** Road-STEAMer recommendation 5 D3.3

***Evidence:*** SENSE D4.3

## *Theme 1b) Develop and organize STEAM learning materials and Teacher Resources in EU languages*

🔵🟡🟢*Action:* systematic organization of open-access STEAM teaching material, practices and assessment, identification of gaps and development in all EU languages with feedback loops for improvement

***Description:*** STEAM material mapping, systematic organization, identification of gaps and development of open educational resources (including modules to be integrated into courses as well as holistic STEAM curricula) to be provided in a user-friendly platform, co-created with teachers and lecturers of diverse educational levels, organized by relevant variables (educational level, language, disciplines, time, inclusivity level, etc.). These materials should prioritise pedagogical relevance, ensuring they are meaningful rather than solely engaging or performative and based on real-life challenges and skills development (instead of knowledge-centred education), according for example to the EU "Lifecomp"and related to a range of careers exploration (in collaboration with external stakeholders including companies and governmental organizations). Starting by gathering already existing resources and making them accessible (in different languages) currently under-utilised resources from previous projects, including EU-funded initiatives, should be systematized in a one-stop-shop digital space where lecturers can easily find materials, share, find peer-to-peer support and provide feedback on pedagogical effectiveness and evidence from assessment that takes into account AI implications for learning and assessment.

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**Example of best practices:**

- Roadstemer map of STEAM practices in Europe https://www.road-steamer.eu/interactive-map-of-steam-practices/
- SENSE-STEAM wiki and “The Learning Companion”: a guide with real-life examples from education, research, and business.
- SciCultureD: It is a free, transdisciplinary planning **tool** designed to help create courses, modules, or activities addressing societal challenges. It combines design thinking with creative teaching methods, using interactive tools to plan playfully. Outcomes can range from public performances to products or community interventions.

***Potential funding instrument:*** Erasmus+

***Suggested time frame***: 2026-27

***Alignment with STEM Education Strategic Plan 2025***: it can support the STEM Panel, and expand it to include STEAM practices (3.2 pg. 8, “In 2025, set up a European STEM Executive Panel at top business/political/administrative level to advise on strategic issues including curriculum modernisation, industry feedback on skills needs across industrial sectors, innovative teaching and content, and embedding academic-business cooperation in STEM education. The STEM Panel would provide actionable recommendations to foster close cooperation between business and STEM education to the European Skills High Level Board and make the results of its work publicly available to any other interested party”.)

***Related policy recommendations:*** Road-STEAMer recommendation 2 D3.3, SEER D7.2

***Evidence:*** SENSE Policy Brief V1, SEER D7.2

🔵🟡*Action:* Research on STEAM teaching material, practices and assessment to investigate and test best practices

***Description:*** Building on the action “systematic organization of open-access STEAM teaching material, practices and assessment, identification of gaps and development in all EU languages with feedback loops for improvement”, systematic data collection on the use of STEAM teaching material and practices to derive the most effective practices in diverse contexts and for diverse learners’ profiles. Specific research should be conducted on teachers/lecturer ability and compliance and encountered challenges for large scale implementation of the STEAM approach in government educational institutions.

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**Example of best practices:**

- STEAMonEdu MOOC: The **project** aims to boost STEAM education by supporting educators' professional development through blended training and an online community. It will create a STEAM education framework, including curricula, competencies, and policies. The project also offers a MOOC (Massive Open Online Course) for educators, guides on best practices, and tools for STEAM policy influencers, focusing on diversity and competence development.
- STEAM Hub Leadership Programme (UK): The STEAM Hub Leadership **Programme** empowers teachers to design STEAM curricula and build industry partnerships while equipping diverse young people with skills for STEAM careers. It fosters an inclusive STEAM community in Camden, influencing policy and regional growth.
- Other examples: SpicE MOOC (focused on inclusivity)

***Potential funding instrument:*** Horizon Europe Pillar 2, cluster 2

***Suggested time frame***: FP10

***Alignment with STEM Education Strategic Plan 2025***: It can expand the European STEM Executive Panel to include the STEAM approach (3.2 pg. 8 encourage the centres and alliances to coordinate their STEM offer and to pool and share their investments in STEM infrastructure, equipment, and educational technologies.)

***Related policy recommendation***: Road-STEAMer recommendation 2

***Evidences***: SEER, Focus group 7, Road-STEAMer D2.3

🔵🟡🟢💡*Action:* Funding for EDTECH startups to promote STEAM

***Description:*** fund EU start-ups to promote STEAM education, modular learning materials with online training for educators, harnessing AI for students customized online learning, potentially online educational activities with students across EU Member states.

***Example of best practices:***

- Arduino: used by more than 50.000 schools and universities, it provides tools for STEAM classes that empower and support students as they progress through middle school, high school, and university through cross-curricular content and open-source approach to learn electronics, programming, IoT, robotics, etc. It is taught at MIT,

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Stanford, ETH Zurich, and Imperial College London and very common in high school STEM programs especially for robotics clubs, science fairs, and coding bootcamps. In Italy it is built into national education programs for technology and engineering.

- AI learning app for educators: Brian AI teaching assistant is a gamified learning app for all educators established in Switzerland and utilized by the University of St. Gallen
- Ed tech programs: Girls code it better is a 45-hour free program for girls at school, one afternoon a week at school.
- More examples: Khan academy

***Potential funding instrument:*** Pillar 3 (I.e., EIT digital transformation)

***Suggested time frame***: FP10

***Alignment with STEM Education Strategic Plan 2025***: It does not align with the STEM strategic plan.

🔵🟡*Action:* deployment and investigation of education and training through citizen science applied to STEAM

***Description:*** identification of citizen science projects applied to STEAM, design and deployment of open science and citizen science projects for STEAM education in secondary and tertiary education, to investigate the effectiveness of citizen science as a learning practice, as well as providing data to current research (i.e., aligned with societal grand challenges).

***Example of best practices:***

- Malta Science in the City: Malta Science in the City is an **Activity** based on an annual festival that blends science, art, and innovation, encouraging public engagement through interactive exhibits, performances, and workshops emphasizing on Citizen Science, inviting the public to actively participate in scientific research and contribute to data collection. The event is part of the European Researchers' Night, helping bridge the gap between science and society.
- SENSE project report on the Citizen Science and Art-Practices Workshop - Deliverable 3.2
- National Geographic Citizen Science projects: Citizen science **projects** where volunteers help collect data for scientific research. These projects span various fields, including ecology and space, allowing individuals to contribute to real-world scientific

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discoveries. Participants can engage in activities like wildlife monitoring, weather observation, and environmental tracking.

- Other projects: MOST (Meaningful Open Schooling Connects Schools To Communities)

***Potential funding instrument:*** Horizon cluster 2

***Suggested time frame***: 2026-27

***Alignment with STEM Education Strategic Plan 2025***: it expands it.

***Related policy recommendation***: SENSE recommendation 2, Policy-Brief-RP1-V1

***Evidence***: Road-STEAMer D3.1, SENSE D3.2, Vohland et al. 2021, SENSE D3.4, Sauermann, H. et al. (2020)

## Priority Area 2: Enhancing the Learning Environment and Teacher Training, harnessing AI and digital tools

### *Theme 2a) Prioritize STEAM Training for Educators and assessment across EU MS*

🔵🟡💡*Action*: training for school heads, school leaders, university deans and policy makers on STEAM

***Description:*** *development and testing of training for school heads, school leaders, university deans and policy makers on STEAM*

***Examples of best practices:***

- The Innovative Leaders Institute is a year-long program designed for school leaders aiming to transform current practices and bring high-quality STEM education to their students.
- Purdue Polytechnic Institute: Master of Science in Technology Leadership and Innovation with a focus on STEM Education Leadership. Graduates of the STEM Education Leadership program are prepared to become leaders in integrated STEM in a variety of positions including university professors, K-12 teachers, policymakers, administrators, informal learning specialists, and others. Participants learn to conduct research that informs practice.

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- McDaniel College STEM Instructional Leader
  This graduate certificate program aimed at preparing educators to take on STEM leadership roles within their schools and districts. The program is delivered online, consisting of 18 credits, and focuses on equipping participants with the skills necessary to make a significant impact in STEM education.
- Navigate EdTech – Choosing Wisely for Learners: a self-paced course designed for school leaders, teachers, and education decision-makers guiding technology purchases and integrationdrafted by OAMK (Oulu University of Applied Science), with the support of European Schoolnet (EUN)

***Potential funding instrument:*** Erasmus+

***Suggested time frame***: 2026-27

***Alignment with STEM Education Strategic Plan 2025****:* this action expands the plan

Alignment with the JRC Science for Policy Brief "STEM and STEAM education, and disciplinary integration: a guide to informed policy action": "Whole school approaches "imply collective and collaborative action in and by a school community to improve student learning, behaviour and well-being, and the conditions that support these"[27] by engaging the local community, school leaders, middle management, teaching and non-teaching staff, learners, parents, and families." (pg. 5)

***Evidence: Douthit, 2021; Abbas et al. 2024; SEER 2.3, SEER focus group 7, SEER D7.2***

🔵🟡***Action:*** deployment and investigation of the STEAM Frameworks for educators and school leaders

***Description:*** development and application of STEAM frameworks, such as the STEAMComp Edu, and possibly aligned with the ESCO classification, for training educators in Europe, at all educational levels, investigating the effectiveness frameworks in increasing teachers/lecturers, school heads, students and schools' proficiency in STEAM subjects and interdisciplinary, trainers' inclusive attitude and ability. Include a multi-level governance component, addressing national training institutions (to be considered as multipliers) to adapt EU resources to specific contexts using tailored content and tools.

***Example of best practices***:

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- STEAMComp Edu: It is a framework that focuses on developing the competencies needed to design and implement effective STEAM education. The framework primarily supports educators in creating inclusive, engaging, and innovative learning experiences for students.
- Other projects *steamonedu*

***Potential funding instrument:*** *Horizon Europe Pillar 2, cluster 2*

***Suggested time frame***: 2026-27

***Alignment with STEM Education Strategic Plan 2025***: aligns with the STEM competence framework which should be enlarged to STEAM holistic competence (3.2 pg. 9 "Developing by 2026 a STEM competence framework for all learners at all stages of education and a taxonomy of STEM skills within the ESCO classification. This will inspire and promote curriculum design, and assessment frameworks for STEM skills.")

***Related policy recommendations:*** Road-STEAMer recommendation 3 D3.3,

***Evidence:*** *SEER D2.2*, *Spyropoulou & Kameas, 2023*

🟡***Action:*** development of networks, centres and alliances (incl. equipment) of teachers/lecturers/head teachers/principals for mutual learning on STEAM

***Description:*** development of networks of teachers/lecturers/head teachers/principals for hybrid (face-to-face and online training) mutual learning on STEAM curriculum and STEAM schools/universities., through both physical and digital collaborative environments, for example through twinning programs, teachers exchanges, MOOCs and face-to-face events for peer-to-peer learning, to promote knowledge exchange and the dissemination of successful STEAM practices.

***Example of best practices:***

- Scientix®: is the STEM Education Community in Europe. It offers the space for all people working in the field of science education to exchange, collaborate and learn from each other. It includes the STEM Alliance, a platform for STEM educators and companies
- EASE – EuropeAn Network of STEAM Educators a non-profit organization that aims at enhancing the work of all educators and teachers in terms of promoting STEAM skills with children, young people and adults in formal and non-formal education.

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- STEAMonEdu MOOC: It is a **project** that aims to boost STEAM education by supporting educators' professional development through blended training and an online community. It will create a STEAM education framework, including curricula, competencies, and policies. The project also offers a MOOC (Massive Open Online Course) for educators, guides on best practices, and tools for STEAM policy influencers, focusing on diversity and competence development.
- School As living Labs (SALL EU project)
- **PHERECLOS project** was a Horizon project, building upon the experience of Children's Universities (CUs) in Europe and beyond. Due to their engagement with children and young people, they help to break down institutional boundaries between universities and the wider society, focusing on open schooling, STEAM education is highlighted. The project developed a complete teacher training toolkit. There is also a collection of good practices.
- *Other examples*: ArtsWork creating seven STEAM networks in SE England

***Potential funding instrument:*** Erasmus+

***Suggested time frame***: 2026-27

***Alignment with STEM Education Strategic Plan 2025***: It expands by including a STEAM focus on the creation of centres and alliances, that could be focused on specific sub-sectors of STEM (3.2 pg. 10 D ii. encourage the centres and alliances to coordinate their STEM offer and to pool and share their investments in STEM infrastructure, equipment and educational technologies.)

***Related policy recommendations:*** ***Road-STEAMer recommendation 4, D3.3***

***Evidence:*** SEER D3.2

🔵🟡***Action:*** EU University alliance on STEAM

***Description:*** Support the creation of a European Universities alliance on STEM and STEAM education.

***Example of best practices:***

- CIVIS: It is Europe's Civic University Alliance, bringing together a community of more than 470,000 students and 58,000 staff members. It is the fruit of the special

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collaboration between 11 leading research higher education institutions across Europe.

- EU STEM coalition in not focused specifically on universities but includes several typologies of European STEM and sTEM actors

***Potential funding instrument:*** European University Initiative; Erasmus+ and National funds

***Suggested time frame***: 2026-27

***Alignment with STEM Education Strategic Plan 2025***: This action aligns with the alliance of universities for STEM education along with the STE**A**M education (3.2, pg. 9 "Working towards a European degree for engineers, by building on the European Universities alliances and ongoing Erasmus+ pilots, considering the needs of employers.")

***Evidence:*** SEER D3.2, SEER D2.2

### 🔵🟡 Action: doctoral network on STEAM

***Description:*** promote the development of doctoral networks across univerisites and with industry partners to promote STEAM competence of PhD candidates and research on STEAM effectiveness, including strong monitoring skills and knowledge of randomized control trials

***Example of best practices:***

- STEP CHANGE: interdisciplinary doctoral program at Politecnico di Milano is a cross-departmental doctoral program in *Science, Technology, and Policy for Sustainable Change*, hosted at the Electronic Engineering department, focused on sustainability and policy implications of technical research
- CoDesign4Transitions: a Marie Skłodowska-Curie Doctoral Networks programme. The doctoral researchers carry out new research and develop skills at the intersection of co-design, sustainability, service and systems design, democratic innovation, and climate transitions
- J-PAL policy action lab: provides training in conducting and evaluation randomized control trials

***Potential funding instrument:*** Marie Skłodowska-Curie joint and industrial doctorates

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***Suggested time frame***: 26-27 and FP10

***Alignment with STEM Education Strategic Plan 2025***: This action aligns (pg.4)

🟡***Action:*** *increase STEAM teaching prestige through fostering schools/university collaborations with local actors*

***Description:*** increase STEAM teaching prestige through fostering structured schools/university collaborations with local actors (industry players, SMEs, civic organizations, governmental institutions) to equip educators with practical knowledge that they can transfer into the classroom and increase the school/university reputation. Develop best practices and investigate the impact of collaborations on teachers/lecturers perceived self-efficacy and reputation.

**Example of best practices:**

- School As living Labs (SALL EU project): Schools As Living Labs" (SALL) is a **project** that adapts open-schooling and Living Lab methodologies to create and test new tools for schools in 10 countries. It involves 412 school communities, aiming to support the design and implementation of living-lab activities, foster community-building, and promote sustainable open-schooling practices across Europe.
- SATO: The Schools Across the Ocean **program**, developed by the University of Exeter, Emirates Literature Foundation, and Khorfakkan University, helps teachers address climate education. Involving 14 schools in the UK and UAE, it engages 400 children to explore ocean-related issues using a specially designed toolkit, fostering community connections and action.
- Other examples: SciCultureD transdisciplinary planning **tool** designed*; University of Exeter's* ***course*** *EFPM839 Transdisciplinary Collaborations for Creative Futures*

***Potential funding instrument:*** Horizon Europe or Erasmus+

***Suggested time frame***: 2026-27

***Related policy recommendations:*** **Road-STEAMer recommendation 4, D3.3**

***Alignment with STEM Education Strategic Plan 2025***: aligns with the European STEM Executive Panel development (3.2 pg. 8, " to foster close cooperation between business and STEM education"; "Supported by Erasmus+, these centres will create dynamic learning

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ecosystems that drive innovation in STEM teaching and learning in schools, by stepping up cooperation with businesses, science museums, STEM organisations, libraries, cultural associations, creative industries, universities and research institutions”)

***Evidence:*** SEER D3.2

## ***Theme 2b) Foster inclusive and supportive Learning Environments harnessing AI and digital tools***

🔵🟡🟢💡***Action:*** The new role of education/teachers/lecturers in an AI-enhanced STEAM education and work environment: arts for fostering equality and wellbeing

***Description:*** research is needed to investigate the changing skills needed by employers due to AI, and how skills in creative thinking, arts and systemic design should be developed in schools/colleges for increasing job readiness, and at the same time increasing students' ability to cope with complexity, increasing inclusion of learners with a broad range of needs (neurodivergence, socio-economic background, sensory sensitivity, genders) and paying attention to mental health (lowering anxiety).

***Example of best practices:***

- Alpha AI powered school: an in presence school in the US, Alpha's 2hr Learning model harnesses the power of AI technology to provide each student with 1:1 learning, accelerating mastery and giving them the gift of time. With core academics completed in the mornings, they can use their afternoons to explore tons of workshops that allow them to pursue their passions and learn real-world skills at school.
- IN-STEAM: A training **course** for educators of the school sector will be implemented and delivered focused on the ELP method, its applications for inclusion and the exploitation of Artificial Intelligence in teaching STEAM.
- AI Empowerment in STEM Education: a course, part of the Erasmus teacher training program, aims to bridge the gap between artificial intelligence (AI) advancements and classroom application, specifically designed for educators across Europe.
- CONNECT: A course, part of the Erasmus teacher training program, aims to bridge the gap between artificial intelligence (AI) advancements and classroom application, specifically designed for educators across Europe.

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- CIVIS AI and STEAM: A comprehensive initiative for students (2025) that integrates AI into STEAM education through physical and virtual learning experiences.
- More examples: STEAM learning resources on AI, STEAMBRACE project (forthcoming)

***Potential funding instrument:*** Horizon Europe Pillar 2, cluster 4 (Digital, Industry and space) and cluster 2 (Culture, Creativity and inclusive society; destination: “Innovative Research on Societal and Economic Transformation”)

***Suggested time frame***: 2026-27

***Alignment with STEM Education Strategic Plan 2025***: This action partially aligns with the STEM Strategy Plan by contributing to the European STEM Executive Panel’s role in designing industry-relevant curricula and developing the STEM Competence Framework using the ESCO classification. It further expands the plan by emphasizing the need to address how digital tools and AI enable to address diverse learner needs, including those related to neurodivergence, mental health,etc  through STE**A**M practices, resulting in a more inclusive and holistic framework. (3.2 pg. 8 l and 9 “Developing by 2026 a STEM competence framework for all learners at all stages of education and a taxonomy of STEM skills within the ESCO classification. This will inspire and promote curriculum design, and assessment frameworks for STEM skills.”)

***Related policy recommendations:*** SEER D7.2

***Evidence:*** *Xu & Ouyang, 2022*, Park & Kwon, 2024, *Kohnke & Zaugg, 2025*, SEER D3.2

🔵🟡💡***Action:*** STEAM cradle to grave

***Description:*** improving the connections from early years (EY) through primary upwards and beyond tertiary in STEAM education to provide a coherent progression for learners from kindergarten to retirement. More research is needed in STEAM practices for secondary and tertiary education and the linkages between educational levels. Learning from STEAM in primary education to be applied into vocational training, secondary education and universities.

***Example of best practices***:

- River as a learning & teaching space - Educational Transition Guide

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- Horizon Europe call "Effective education and labour market transitions of young people"

***Potential funding instrument:*** *Horizon Europe Pillar 2, Erasmus+*

***Suggested time frame***: FP10

***Related policy recommendations:*** SENSE recommendation 2 & 5, D5.5, SENSE D6.4

***Evidence:*** Tytler et al. 2008; Nugent, et al. 2015, Shaby, et al. 2021;

## Priority Area 3: STEAM literate citizens - aligning STEAM education and career design with societal and industrial needs

### ***3a) STEAM career design and integrated learning pathways***

🔵🟡🔴Action: STEAM (lack of) career selection

***Description:*** investigate the motivation of students exposed and not exposed to STEAM education and open schooling approaches integrating social and corporate collaborations, in selecting a STEAM education (secondary/vocational/tertiary) and a career in STEAM: identify barriers, enablers and biases.

***Examples of best practices:***

- CAREER project funded by an ERC Starting Grant from the European Research Council (ERC). *From School to Career: Towards A Career Perspective on the Labor Market Returns to Education* (CAREER) is a five-year research project (2021-2026), funded by the European Research Council. It aims to develop a better understanding of workers' employment trajectories in the context of changing labour markets.
- Education and Training Monitor 2024 (Finland): Finland education focus on STEM does not increase STEM uptake.
- Pew Research Center survey on why more American students do not pursue STEM majors

***Potential funding instrument:*** Horizon Europe Pillar 2, Cluster 2 destination 3

***Suggested time frame***: 2026-27

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***Alignment with STEM Education Strategic Plan 2025***: This action partly aligns with the STEM strategy plans where it expands the scope of proposed action of identifying the underlying the pre-existing causes and motivation of students on how to attract them to STEM education through STE**A**M approaches (3.2 pg. 8, “better anticipating sector-specific skills needs as part of the future European Skills Intelligence Observatory and by leveraging the common European Data Space for Skills.)

***Evidence:*** Holmegaard, et al. 2014; Mandalapu & Gnog, 2019; Wang, Ye & Degol, 2017; Tandrayen-Ragoobur & Gokulsing, 2022

🔵🟡🔴💡***Action:*** STEAM life and career design

***Description:*** Longitudinal study to design and test support for STEAM career design and exploration across the learner's journey (cradle to grave) aligned with EU priorities (Green Deal, competitiveness, security, democracy) and job market needs. Define and test a replicable methodology for career exploration and life design with a focus on STEAM.

***Examples of best practices:***

- Designing Your Life: Through this **program**, students are able to identify their ideal life and career, in collaboration with executive coaches and academic advisors to design an individualized, goal-driven pathway.
- STEAMULE: The STEAMULE **project** challenges career-related prejudices, such as gender stereotypes, to inspire young people to explore diverse career options. It encourages informed reflection on career choices through discussions. Additionally, the project supports educational teams by providing training in teaching practices and new skills, aligned with the Pact for Teaching Excellence and polytechnic education goals.
- STEAMiE: an educational game engine developed by Ohio University to expose middle school students to science career fields.

***Potential funding instrument:*** Horizon Europe Pillar 2

***Suggested time frame***: 2026-27 + FP10

***Alignment with STEM Education Strategic Plan 2025***: This action expands the plan.

***Related policy recommendations:***

***Evidence:*** Road-STEAMer D7.4

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🔵🟡🔴💡***Action:*** STEAM career exploration centers

***Description:*** Experiment and test the creation of career exploration centers that students can attend from the last year of middle school to university, substituting a part of class hours, to promote an informed understanding of career options and experiences, focused on careers in high demand and in relation to EU priorities (i.e, the Green Deal, security but also entrepreneurship). The centers offer structured activities between secondary and tertiary education, or teachers/university lecturers training on career design support to students, which are investigated through longitudinal studies to test the effectiveness in particular for vulnerable students. The centers promote lifelong learning beyond the traditional school years and encourage inclusion of local actors.

***Example of best practices:***

- Gereau Center for Applied Technology and Career Exploration: At the Gereau Center, career exploration is integrated into the eighth-grade (**curriculum)** through project-based learning, specialized courses, and hands-on experiences. Students explore fields like engineering, design, and medical studies while working on real-world projects. They engage with industry professionals, use applied technology, and develop critical thinking skills.
- Career Exploration in high school: whole or half year option, students experience up to 8 different career programs, for 5 weeks each. It is a public program provided in 4 locations by the US  Board of Cooperative Educational Services (BOCES) of ERIE 1 (19 school districts of NY State)
- Explore STEM and pathways to STEM: extra-curricular programs offered by a private educational travel America company  that provides n20 different career, leadership, and technology programs that take place in cities across the United States and the world part of the WorldStrides company.
- BECOME: a service for primary and secondary schools, developed by the Australian Government. It is an internationally awarded, evidence-based program that supports young people in schools by providing the time, structure and tools to think broadly and deeply about their ideas for the future. It also provides course online for educators.
- Amazon future engineer: free, interactive, virtual field trips that inspire students to pursue careers of the future by exploring Amazon's technologies.

***Potential funding instrument:*** Horizon Europe Cluster 2 and Erasmus+

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***Suggested time frame***: 26-27 and FP10

***Alignment with STEM Education Strategic Plan 2025***: This action expands the plan, in particular the"STEM skills foundries" centres through which students experience and explore in-demand STEM career options in relation to EU priorities with the inclusion of local actors and take informed career choices. (3.2 pg. 10, “Pilot in 2026 the development of STEM skills foundries in strategic sectors by involving companies to mentor young student entrepreneurs, in cooperation with vocational education and training providers and with higher education institutions, providing them access to their laboratories, technical infrastructures and equipment, development of intellectual property (IP), as well as facilitating access to venture capital. This should also bring together VET and higher education providers, talented VET and higher education students and the world of finance, particularly venture capital”)

***Evidence:*** Visher et al., 2013.

## 3b) Encourage agile partnerships with Industry and organizations to address industrial and societal needs

🟡🔴🟢***Action:*** Joint diplomas, degrees, microcredentials with industry/civic organizations, recognized at EU level

***Description:*** Map and investigate best practices of joint programs between secondary/tertiary education providers with companies and/or civic organizations, in providing technical, agile and solid education aligned with market developments, credited by educational institutions and partially funded by companies and organizations. Investigate how educational institutions can effectively become facilitators of the establishment of academic programs that are co-designed with – and co-funded by - industrial and societal players that guarantee national and EU learning standards for accredited education, including EU microcredentials for lifelong learning.

***Example of best practices:***

- IB CP: At secondary school level: The International Baccalaureate Career-related (**Programme)** (IBCP) is an education framework for students aged 16-19, combining academic study with career-focused learning. It includes traditional courses, career-related studies, personal and professional skills development, service learning,

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and a reflective project, preparing students for higher education, apprenticeships, or employment.

- Universities of Applied Sciences /Fachhochsule (Germany and central Europe)/ Haute Ecole Spécialisée (Switzerland) /ITS (Italy) can promote applied tertiary education in joint programs with industry and non-commercial partners. Example: ITS Academy Machina Lonati provides Secondary and Tertiary vocational education in STEM (es. fashion tech).
- *More examples*: Alfa Academy school-Industry partnership, Double degrees, such as Politecnico di Milano Double degree in Management Engineering and Product Service System Design.

***Potential funding instrument:*** Horizon Europe Cluster 2 and Erasmus+

***Suggested time frame***: 26-27 and FP10

***Alignment with STEM Education Strategic Plan 2025****:* This action aligns with the STEM strategy plan to design effective joint programs and microcredentials collaborating with educational institutions, businesses and industries. (3.2 pg. 10, " i) boost the available range of joint programmes and microcredentials in STEM, including with a STEAM (science, technology, engineering, arts, and mathematics) educational approach")

***Related policy recommendations:*** Road-STEAMer recommendation 6

**Evidence:** SEER D3.1, "Professional Degrees obtained in cooperation with industry/university: Some mentioned that professional degrees obtained through cooperation between industry and universities could be very effective." SEER D3.2

🔵🟡***Action:*** Multi-stakeholder collaborations through open-schooling

***Description:*** multi-stakeholder collaborations through open-schooling are a core component of the STEAM approach, based on open schooling environment and living lab practice within an empowering partnership based on local level collaboration between formal, non-formal and informal technology and science education providers, enterprises, local businesses, cultural institutions, and civil society (also called "STEAM Learning Ecologies"; ref. SEER D2.2, SEER D2.1, SLE projects). Research should investigate how STEAM Learning Ecologies can sustain the implementation and cost of STEAM teaching and learning practices, and how it can foster a systemic change in the education system through multi-stakeholder collaborations. The investigation of the effectiveness of partnerships could

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include sharing or sponsoring spaces and equipment, as well as mentorship programmes to foster meaningful interaction between professionals, scientists, and students, ensuring that students gain insights into real-world applications of their learning. Partnerships should align educational outcomes with labour market needs, particularly in sectors requiring both technical and creative skills, such as digital innovation, design, and renewable energy, as well as considering top skills that can foster employment (i.e., Data Analysis and Interpretation; Artificial Intelligence (AI) and Machine Learning; Cybersecurity; Cloud Computing; Programming and Software Development; Analytical/Mathematical Thinking; People Management and Leadership; Communication and Teamwork; Adaptability & Innovation; Technical Proficiency and IT Skills (SEER project).

**Example of best practices:**

- SALL: Schools As Living Labs" (SALL) is a (**project)** that adapts open-schooling and Living Lab methodologies to create and test new tools for schools in 10 countries. It involves 412 school communities, aiming to support the design and implementation of living-lab activities, foster community-building, and promote sustainable open-schooling practices across Europe.
- OSOS: The OSOS Open Schooling Model helps school leaders explore ways to transform schools into innovation hubs, enabling effective co-design and use of educational content, tools, and services for personalized science learning and teaching.
- *More examples:* Agreement between Smithsonian and Ukraine Ministry of Education and Science, InChildHealth, Polifactory: Fablab of Politecnico di Milano

***Potential funding instrument:*** Horizon Europe Cluster 2 all pillars and Missions, Cluster 3 EIT and EIE, and Erasmus+

***Suggested time frame***: 26-27 and FP10

***Alignment with STEM Education Strategic Plan 2025***: This action supports the plan expanding it to STEAM (3.2 pg. 8, In 2025, "The STEM Panel would provide actionable recommendations to foster close cooperation between business and STEM education")

***Related policy recommendations:*** SENSE recommendation 2 & 4 (SENSE D5.4), Collaboration between Education and Industry (SEER D3.2)

***Evidence***: SENSE D5.5, SEER D3.2

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🔵🟡***Action:*** integrate STEAM education in Horizon Europe Pillar 2 calls, in particular Cluster 2 and the Missions

***Description:*** integrating STEAM education into the Green Deal initiatives and in Horizon Europe Pillar 2 calls, suggesting or requiring projects to include schools and universities in their activities such as for citizen science or living labs, and&or to translate the project output into teaching material such as projects or case studies. Schools and universities can contribute to research projects while explicitly promoting critical thinking and the ability to reflect on the ethical, political, and societal dimensions of technology and design, recognising that these are not neutral.

***Example of best practices:***

- HORIZON-MISS-2023-OCEAN-01-11: The HORIZON-MISS-2023-OCEAN-01-11 is a funding opportunity under the Horizon Europe program, aimed at using arts and creative sectors to engage the public in protecting and restoring aquatic environments. Projects are encouraged to collaborate with the Creative Europe program and align with the New European Bauhaus initiatives. The 5 EU Mission financed under Horizon Europe Pillar 2 could be requested to translate the projects' work into actionable educational material and activities specific to foster STEAM for secondary and tertiary education in relation, to foster the linkage and flow of information between funded projects and challenge-based education based on societal needs (Missions: Cities, Adaptation, Soil, Ocean, Cancer).
- **LOESS Project** (Mission Soil)**:** hands-on soil education through community-engaged research and learning, includingactivities tailored for schools to foster practical understanding of soil-related issues and the "Mooc soil education: an integrated stem approach"
- **Neuroclima** (Mission Adaptation): the project will deliver three toolkits for stakeholders and citizens for the green transition towards combating climate change: (1) participatory design, (2) creative writing and (3) cinematography, animation, and performing arts. These toolkits foster inclusive and widespread participation, educate citizens of all ages, developing essential skills among educators, policymakers, decision-makers, and others in public governance to educate citizens about climate-related initiatives, gather feedback, and promote innovative participatory policy co-design.
- **PREPSOIL Project** (Mission Soil): Aims to raise awareness about soil health among school students and teachers and other audiences. It seeks to engage educational

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institutions in understanding the importance of long-term soil health and sustainable land management practices.

***Alignment with STEM Education Strategic Plan 2025***: This action expands the plan to leverage existing funding instruments

***Potential funding instrument:*** Embed STEAM and industry/societal needs in Horizon Europe Pillar 2, cluster 2 destination 3 calls on education and Missions

***Suggested time frame***: 26-27

***Related policy recommendations:*** Road-STEAMer recommendation 5, SENSE recommendation 5

***Evidence:*** SEER D3.2, Cedefop (2023c)

🔵🟡🟢*Action:* STEAM entrepreneurship education

***Description:*** research to investigate how to foster entrepreneurship in STEAM through secondary and tertiary programs, for example developing highschool prgograms and uniersity degrees focused on supporting learners to develop thier own businesses.

***Example of best practices:***

- ***BUILD* program:** entreprneship prgrams from few hours to 3 years, embedded int he school program (USA)
- ***Switzerland Venture program:*** *the state-fianced start-up programs, competition and funds are potentially recognized as college credits and promoted in universities with a focus on technological startups*
- ***High School Entrepreneurship*** *program at Berkley university: 2 week program for 50 students per year supported to develop a business plan at the University campus*

***Alignment with STEM Education Strategic Plan 2025***: This action aligns with the plan: “Provide dedicated training on innovation, entrepreneurship and IP management to 200 000 STEM higher education students, academics and staff by 2028, building on the EIT Higher Education Institutions Initiative in synergy with the European Universities alliances and the EIT knowledge and innovation communities.” (pg. 10)

***Potential funding instrument:*** Horizon Europe Pillar 2

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***Suggested time frame***: 26-27

***Related policy recommendations:*** Road-STEAMer recommendation 6

## Priority Area 4: transdisciplinary, effective inclusive STEAM education paradigms promoting equity

### 4a) Flexible, inclusive and supportive STEAM education

🟡🔴🟢💡 *Action*: Update the Digital Education Plan to have a broader definition of inclusivity

***Description:*** Revise the Digital Education Plan ensuring that it covers all underrepresented groups to access digital education and a more complete definition of inclusivity in addition to gender(s), to consider physical and mental disabilities, neurodivergence, diverse abilities, sensory needs, socio-economic background, mobility limitations, language and literacy competence. In particular, action 13 of the DEAP should be expanded to incorporate more diversity not just across the gender spectrum, but incorporating other identity lines such as race, disability and class in a truly intersectional approach. In this sense it is essential to ensure that learning materials for digital education are designed with a multiplicity of needs in mind, adopting a Design for All approach. The shift to more inclusive practices should be reflected in KPIs and other targets, moving beyond a mere increase in the number or percentage of women (or other underrepresented groups) studying, working and doing business in digital and STEM fields, towards more comprehensive measures of inclusive representation , including at a minimum measures of diversity at all level of the organisation, within decision-making bodies, pay equity and chances of career advancement including diverse abilities and sensory needs, as well as (reduction in) cases of discrimination and harassment.

***Potential funding/policy instrument:*** Digital Education Plan

***Suggested time frame***: 2026

***Related policy recommendations:*** Road-STEAMer recommendation 7

***Evidence:*** “in the Digital Education Action Plan 2021-2027 (DEAP), STEAM is mentioned in Action 13 as a way to increase women’s participation in STEM studies and careers – in other words, as a mere instrument to improve the outcomes of STEM education, without making

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fundamental changes." Road-STEAMer, Díaz-García, C., González-Moreno, A., & Jose Sáez-Martínez, F. (2013)

🔵🟡🟢💡***Action:*** An economic case for inclusive STEAM education in secondary and tertiary education

***Description:*** Calculate the economic case of increasing STEAM education at secondary and tertiary level to provide evidence for policy making, and specifically the economic case for developing learning paths and environment that are inclusive for underrepresented groups, including women and all genders, people with disabilities, autism, ADHD, sensory sensitivity, low socio-economic status, migration background, working students, mothers, etc., in partnership with industry players and other organizations. A longitudinal study (control trial) can inform future policies on the economic advantages of developing tailored skills development and career support for STEAM experts that are otherwise unemployed or underemployed because of vulnerabilities.

***Example of best practices:***

- Learning programs suitable for twice-exceptional students: Bridges Academy is a leading school for gifted and twice-exceptional students (2e). Our students have an individual mix of high abilities and learning challenges.
- LiNC-IT: Employment program that collaborates with government, nonprofits, and employers to provide employment opportunities for individuals with Autism Spectrum Disorder
- Companies and programs with inclusive culture and programs: Auticon, Microsoft's Neurodiversity Hiring Program, SAP's Autism at work, IBM's Neurodiversity Advancement Initiative, Google Austism Career Program in collaboration with the Stanford Neurodiversity project, Specialisterne

***Potential funding instrument:*** Horizon Europe Cluster 2 destination "Innovative Research on Social and Economic Transformations"

***Suggested time frame***: 26-27 and FP10

***Alignment with STEM Education Strategic Plan 2025***: This action expands the plan to broaden its impact on under-represented and marginalized groups and increase employability.

***Related policy recommendations:*** Road-STEAMer recommendation 6

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***Evidence***: [SEER D3.1](), [Perales & Aróstegui, 2024]()

🔵 🟡 💡**Action:** Effectiveness of STEAM and transdisciplinary learning paradigms to support learning preferences and needs of diverse learners to increase inclusivity and improve skills

***Description:*** Longitudinal study to systematically test a variety of STEAM and transdisciplinary learning options (Quigley et al., 2019) to support diverse learning preferences and diverse assessment (skills-based), integrating the EU Digital Compass and Life Comp and diverse modalities such as blended learning and hybrid learning. To support the EU and Member States in defining and adopting a unified STEAM education strategy, research should be conducted on the effectiveness of educational paradigms and available learning options to replace or heavily revise traditional national education paradigms. Interdisciplinary skills-based (rather than knowledge-based) education, focused on real world challenges, can provide several economic benefits to European nations, off-setting the cost of a systemic change to the EU educational system. Research should test (i.e., with experimental trials) multiple STEAM and transdisciplinary (existing or new) learning approaches and modalities (online, blended) and evaluate which approach is most effective for which type of learner, including learners with disabilities or belonging to vulnerable groups (incl. intersectionality); such programmes include Universal Design for Learning (to be applied to STEAM education), blended learning, the International Baccalaureate with STEM (in particular the Career-related Program), etc.

***Example of best practices:***

- [UDL-BOE Blended learning in schools](): a project funded by Erasmus+ it focuses on developing practical tools to help teachers deliver effective and engaging learning in a digital space, addressing two key areas: inclusion and digital pedagogical competences, with the main target group being second-level teachers. The approach will be based on the Universal Design for Learning (UDL) framework (Cast.org), an inclusive approach to teaching and learning that offers all students an equal opportunity to fulfil their potential. This framework offers students different options for accessing, building and internalising learning.

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- H-Farm: a **secondary education teaching program** based on the holistic International Bacchlaurate curriculum expanded to include STEM in collaboration with the Italian Institute of Technology (IIT), integrates science, research, and innovation, fostering interdisciplinary learning and technological advancements in education and cultural heritage. The International Bacchalaurate has proven more successful than national curricula in improving students skills (Dulun& Lane, 2023).
- School of Humanity (online middle and high school): developed int he US with learning hubs worldwide, it partners with schools and with industries. It received several awards and it is based on a balance of interactive online learning, with time for offline, parent-led activities Instead of subjects, learners have daily workshops.
- *More examples:* IN-STEAM: An INnovative pedagogical method for an INclusive STEAM education; International Baccalaureate transdisciplinary program, IB in public schools; Teacher Academy course "Universal Design for Learning: Strategies and Digital Tools to Support All Learners" and "Multi-Tiered Support System (MTSS) and Universal Design for Learning (UDL) for Academic and Behavioral Growth"
- ***SPICE academy*: training program**, which is dedicated to empowering educators on their journey towards becoming Inclusive STEAM educators

***Potential funding instrument:*** Horizon Europe Cluster 2 destination "Innovative Research on Social and Economic Transformations" and Erasmus+

***Suggested time frame***: 26-27 and FP10

***Alignment with STEM Education Strategic Plan 2025***: This action expands the plan to broaden its impact on under-represented and marginalized groups and increase employability.

***Related policy recommendations:*** SEER D7.2, Road-STEAMer recommendation 7 D3.3

***Evidence:*** Quigley et al., 2019; Thoma, Farassopoulos & Lousta, 2023, Dulun& Lane, 2023***,*** Road-STEAMer D4.2

🔵🟡💡**Action:** Learning Environment design and its impact on learning outcomes

***Description:*** Research on the physical environment impact on educational outcomes for a variety of students' needs and abilities (including disabilities) to design STEAM spaces that consider the overall quality of the learning experience alongside functionality, and promote participatory, reflective design strategies that create spaces reflecting the views and feelings

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of all participants. The traditional classroom is a “symbol” for a particular educational approach; a STEAM space is essentially a “not-a-classroom” space (SENSE) that can include labs, outdoor learning and learning through experiences with the school/university community. Investigate diverse pathways into science education through inclusive spaces, by creating platforms and opportunities for students and the school community to contribute to the design of learning environments. Learning spaces should be supported by evidence-based design of inclusive learning environments that are suitable for learners and lecturers with high sensory sensitivity or other needs (moving, privacy, rest, sensory rooms, labs) and its relation to making spaces accessible to everyone (SENSE), supporting wellbeing for all, through a positive impact on mental health.

***Example of best practices:***

- OTTER: an Ersmus+ project on learning outside the classroom, specifically to improve scientific knowledge, get closer to STEAM subjects. It provides toolkits and guidelines practitioners can use to teach outside the classroom.
- Labs: UCL Academy is a specialist school emphasizing a STEAM-focused curriculum. The school offers specialized facilities, including science laboratories, engineering suites, and performance spaces, to support its interdisciplinary approach to education
- SENSE project Deliverables: D5.1 Scoping report on STEAM spaces ; D5.2. Report on Evaluation of space strategies for the STEAM Roadmap; D5.3 Self-experimentation toolkits and design principles for STEAM spaces ; D5.4 Policy recommendations: STEAM spaces and the New European Bauhaus
- Sensory and Quiet rooms: Education institutions have sensory rooms or quiet rooms to be used for meltdown prevention
- Outdoor learning: Examples: The Green School (Bali), UBC MOOC on STEM outside
- *More examples:* SPICE Academy, STEAM.SENSE lab Odyssea

***Potential funding instrument:*** Horizon Europe Cluster 2 and Erasmus+

***Suggested time frame***: 26-27 and FP10

***Alignment with STEM Education Strategic Plan 2025***: This action expands the plan to promote more inclusive learning to increase the uptake of STEM education.

***Related policy recommendations:*** SENSE recommendation 1, D5.4,

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***Evidence:*** SENSE D5.1**,** SENSE D5.4, Aron, 2002; McAllister, 2010; Byers, Terry, Wesley Imms, and Elizabeth Hartnell-Young. 2014; Pluess, 2019; Butera, et al., 2020

### *4b) Promote Intersectional Approaches in STEAM, improving accessibility*

🔵🟡🟢💡**Action**: Investigate the efficacy of increasing hybrid and blended learning to make STEAM educational more accessible

***Description:*** Research should investigate how hybrid and blended learning formats can address barriers, which can be physical or digital, to make STEAM curriculum, educational resources, tools, and facilities equally available to all students. Research should investigate the impact of policies to increase hybrid and blended (online and physical learning - beyond current only online or only physical learning) STEAM curriculum offers, and their efficacy in increasing accessibility to students, in particular from learners with difficulty to physically access secondary and tertiary education due to distance from the school or college, or the need to work or to be caregivers for children (mothers) or language barriers.

***Example of best practices:***

- ***Blended learning high school:*** Dwight Schools offer a Blended Learning **Program**, combining traditional classroom education with online learning through Dwight Global Online School. This allows students from any location to pursue rigorous academics and personal passions simultaneously, with flexible course options.
- **UDL-BOE Blended learning in schools**: a project funded by Erasmus+ it focuses on developing practical tools to help teachers deliver effective and engaging learning in a digital space, addressing two key areas: inclusion and digital pedagogical competences, with the main target group being second-level teachers. The approach will be based on the Universal Design for Learning (UDL) framework (Cast.org), an inclusive approach to teaching and learning that offers all students an equal opportunity to fulfil their potential. This framework offers students different options for accessing, building and internalising learning.
- Revere High School (USA): successfully transformeda a low-performing school to winning several awards, through a blended learning approach,setting it as a national (US) example of the type of programmatic systems change needed to move our schools forward, through flipped learning, iPads, SMARTBoard and monitoring progresses with iWalkthrough
- SORA online middle school and  highschool: Students meet in live, synchronous classes sessions where they dive into real-world topics that interest them. These

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classes blend disciplines and focus on hands-on, project-based learning instead of tests.

- Evening/night schools and college courses: Spanish universities regularly offer college courses during the evening for regular degrees (not only for executive or shortcourses), to support working students pursue college education.
- *Other examples:* SPICE academy

***Potential funding instrument:*** Horizon Europe Cluster 2 and Erasmus+

***Suggested time frame***: 26-27 and FP10

***Alignment with STEM Education Strategic Plan 2025***: This action expands the "Pilot STEM education centers ecosystem" by suggesting the use of blended and hybrid learning, increasing accessibility for learners both physically and virtually. (3.2 pg. 9, "Pilot STEM education centres for school education, including VET schools, across the EU with the goal of improving how STEM is delivered and experienced in primary and secondary education")

***Related policy recommendations:*** Four key social dimensions: co-creation, access, agency, and most importantly identity (SENSE). National governments should ensure that inclusion in education acknowledges the intersecting challenges faced by students who belong to multiple underrepresented groups. This includes addressing language and cultural barriers to make STEAM education more accessible and relevant to diverse populations (Road-STEAMer).

***Evidence***: European Education Area report: how blended learning can make education more inclusive; EU Blended mobility implementation guide for Erasmus+ higher education mobility KA131 guidance; Allan, 2019; Ahuja et al. 2023, Dziuban et al. 2018, SEER D3.1

🟡***Action***: mentorship programs and scholarships for underrepresented groups

***Description:*** research the effectiveness of implementing targeted interventions for vulnerable and underrepresented students in STEAM, such as mentorship programs, peer to peer buddy programs, scholarships, access to a range of educational options and approaches (including part-time and micro-credentials) that can support a variety of their needs such as reduced mobility to diverse abilities, safety, religion or cost, sensory issues, anxiety, neurodiversity, and socio-economic status.

***Example of best practices:***

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- *Scholarships (from sponsors):* Google's Women Techmakers: Google offers scholarships **programs** to women in computer science and related fields, providing financial support, mentorship, and networking opportunities. A notable scholarship is the Google Anita Borg Memorial Scholarship, honouring Dr. Anita Borg's legacy in advancing women in tech.
- *Resources, mentorship and networking:* Latinas in STEM: **Programme** founded in 2014 by Dr. Christine M. Rivera, Latinas in STEM empowers Latina women in STEM fields by offering resources, mentorship, and networking opportunities to support their success in education and careers.
- *Schools and Universities support programs:* Stepchange: mentally healthy universities framework of Universities UK (whole university approach), Politecnico di Milano programs for students with diverse abilities.
- MESA Community support program for disadvantged students: **Mathematics, Engineering, Science Achievement** (**MESA**) is an academic preparation program for pre-college, community college and university-level students. Established in 1970 in California, the program provides academic support to students from educationally disadvantaged backgrounds throughout the education pathway so they will excel in math and science and ultimately attain four-year degrees in science, technology, engineering or math (STEM) fields. MESA has been named among the top five most innovative public programs in the USA: an initiative of the Ford Foundation, the Kennedy School of Government at Harvard University, and the Council for Excellence in Government

***Potential funding instrument:*** Horizon Europe Cluster 2 and Erasmus+

***Suggested time frame***: 26-27 and FP10

***Alignment with STEM Education Strategic Plan 2025***: This action does not align with the STEM strategy plan, but it can expand by including vulnerable and under-represented groups to their mentorship program along with scholarships that can improve the attractiveness to STEM careers and education.

***Related policy recommendations:*** Road-STEAMer recommendation 8 D3.3: While gender diversity remains critical, future policies should adopt a more comprehensive approach to inclusion in STEAM education, addressing barriers faced by ethnic minorities, low-income students, and students with disabilities providing access to a range of educational options

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and approaches that can cater the variety of their needs, and provide funding to monitor the effectiveness of those measures. (Road-STEAMer)

**Evidence:** Tandrayen-Ragoobur & Gokulsing, 2022; SEER D3.2, The_SEER_FocusGroup05 SENSE D6.1

# Conclusions

The document outlines the first version of the Road-STEAMer Roadmap for STEAM Education in Horizon Europe, the main output of the project. Specifically, the roadmap provides concrete actions to promote STEAM in various EU funding streams, including in particular recommendations for FP10.

The development of the roadmap started with a synthesis of the project results involving a review of all previous project deliverables complemented by additional analysis, and whose results are mainly summarised in sections1.2 to 1.5. This work then fed into a collaborative policy roadmapping co-creation process involving a series of 14 iterative workshops and 4 dialogues with stakeholders.

Based on the identification of policy recommendations (D3.3) and insights from stakeholders, the roadmap suggests a systemic change in Education through an orchestrated series of 30 actions, following the approach of the EU Mission for systemic change, and is organised into the following four key priority areas:

1. Strengthening the STEAM Curriculum at National and EU levels
    a. Redefine STEAM as a Holistic Curriculum
    b. Develop STEAM Learning Materials and Teacher Resources
2. Enhancing Teacher Training and Learning Environments
    a. Prioritize STEAM Training for Educators
    b. Foster inclusive and supportive Learning Environments harnessing AI and digital tools
3. Cultivating STEAM-literate Citizens
    a. STEAM career design and integrated learning pathways
    b. Encourage agile partnerships with Industry and organizations to address industrial and societal needs

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4. Promoting Equitable and Effective Transdisciplinary STEAM Education
    a. Flexible, inclusive and supportive STEAM education
    b. Promote intersectional approaches in STEAM, improving accessibility

The resulting roadmap is visually structured as a matrix, with the above-listed priority areas forming the columns and funding instruments the rows. Each intersection in this matrix details actions across two timeframes: the current EU funding program (until 2027) and the subsequent FP10 (2028-2034). Overall, the roadmap contains 30 concrete actions, each detialed with an indication of the most suitable EU funding instruments, tentative time frame and best practice examples emerging directly from Road-STEAmer work (deliverables, stakeholder insights), as well as recommendations from other projects funded under the same call, and from scientific evidence more broadly. Furthermore, actions also contain a specification on how it relates to the STEM Education Strategic Plan (aligning to it or providing actionable ideas for expansion).

The interactive visual overview of the Roadmap provides an easy summary of those actions, with the colour coding and clear indication of timeframes aiding decision-makers to identify the ones that are more closely linked with their respective areas of work. Links to relevant examples further help in bridging the gap between theory and practice.

Following the release of this deliverable, the Road-STEAMer project team will continue working on the development of the actions' impact, user testing, feasibility analysis and policy alignment, which will feed into the second and final version of the Roadmap (D5.2) to be released before the end of the project in August 2025. This final deliverable will also expand on the interconnections between the Road-STEAMer roadmap and those developed by its "sister projects" SENSE and the SEER.

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# Appendix

## Appendix A: Project participatory approach and methodology

The overall purpose of the participatory approach adopted by Road-STEAMer, outlined in the dedicated deliverable, is to ensure that the STEAM roadmap which the project will develop will be grounded on shared knowledge and understanding among stakeholders of the relevant concepts, contexts, conditions, needs, and policy gaps in Europe's science education landscape, as well as of the opportunities arising through STEAM for integrated science learning approaches and synergies between school education, higher education, informal and non-formal science education, and the world of business, which will bring students and citizens in closer contact with Europe's big challenges.

To this end, the participatory methodology paves the road for the development of the Road-STEAMer Stakeholder Community, which will consist of individuals, groups and organisations from different parts of Europe active in the worlds of school education, higher education, informal and non-formal science education, research, innovation, creativity, the arts, business, as well as the civil society, citizens and policy makers.

The aim is to engage a minimum of 1500 stakeholders, and up to now the targets have been achieved in most of the stakeholders' categories. For those that still are under the target the consortium has already planned for relevant activities and is foreseen that the targets will be achieved.

| Area | Stakeholder groups | Quantitative targets | Results / Status |
|---|---|---|---|
| School education | School education professionals and organisations *(teachers, headteachers, teacher trainers, other school education experts, schools, school authorities, teacher training institutes, teacher and school networks, etc.)* | 50 school education teachers/experts | 187 |
| | Formal education learners and families *(school education students and their parents)* | 550 school education students | 1570 |

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| | | | |
|---|---|---|---|
| Higher education | Higher education professionals and organisations *(academics, university researchers, other higher education experts, universities, higher education authorities, etc.)* | 50 higher education teachers/experts | 126 |
| | Formal education learners *(higher education students)* | 250 higher education students | 65 |
| Informal/non-formal education | Informal and non-formal science learning professionals and organisations *(educators, communicators, other experts in science museums and science centres, after-school programmes, camps, festivals, clubs, etc.)* | 50 informal/non-formal science educators | 34 |
| | Informal and non-formal science learners and families *(informal/non-formal science education learners/audiences, young learners' parents)* | 250 informal/non-formal science education learners/audience | 906 |
| Research and innovation | Research and innovation professionals and organisations *(researchers, innovation actors, innovation experts, research organisations, research infrastructures, innovation centres, etc.)* | 50 research and innovation community members | 84 |
| Creativity and arts | Creative industries professionals and organisations *(designers, content creators, gaming experts, makers, creative industry businesses and institutions, etc.)* | 50 creative community members | 4 |
| | Artists and arts organisations *(theatre/dance companies, galleries, museums, etc.)*, arts education professionals and institutions | | 18 |
| Entrepreneurship and business | The world of entrepreneurship and business *(businesspeople, companies, etc.)* | 50 world-of-entrepreneurship-and-business members | 27 |

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| | | | |
|---|---|---|---|
| Civil society | Citizens, civil society, NGOs and other third sector actors | 100 citizens, third sector organization members | 577 |
| Policy making | Education, research and innovation policy makers *(at various levels from local to European)* | 50 policy makers at various levels (local to European) | 83 |
| | **TOTAL** | **1500** | **3681** |

Further, the participatory methodology defines processes intertwined with all project work strands contributing the development of the roadmap, which will systematically engage members of the Road-STEAMer Stakeholder Community in active exchange, dialogue and co-creation with the consortium.

Within this context, the participatory methodology of Road-STEAMer has been developed to consist of the following five elements:

1. Road-STEAMer co-creation workshops
2. Road-STEAMer community events
3. Road-STEAMer dialogues
4. Road-STEAMER community development
5. Technologies supporting participation and co-creation

The Road-STEAMer consortium has already organised numerous events and tried to develop and operate a community of practice both in person (elements 1-4 above) as well as virtually (element 5 above, using the Road-STEAMer Platform, https://community.road-steamer.eu/?locale=en). All the details about the participatory methodology, the methodology to monitor the communities operation as well as the operation of the Road-STEAMer Platform are described in D1.1, D1.2 and The Road-STEAMer Community of Practice Suite User Guide.

## Roadmapping workshops of WP5

Specifically for WP5 related to the development and prototyping of the roadmap described in Section 1.6, 14 workshops and additional 3 dialogues have been carried out for a total of 79 participants in the workshops plus 4 individual dialogues. Workshops were conducted with the visual support of the roadmapping template and lasted between 1 and 2 hours, from 2 to


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34 participants. They were conducted from July 2024 to April 2025. Specifically the participants belonged to:

- the world of business and industries: 11
- higher education students: 34
- higher education lecturers and researchers: 13
- special education students: 2
- special education educators: 2
- Policy makers: 11
- Informal education: 4
- Civic organizations (on disability): 6

Further detials will be reported in the dedicated deliverable D1.3 at the end of the project that will include the testing.

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# Appendix B: STEAM Policies and analysis

## Introduction

While much of the Road-STEAMer project is focused on pedagogy, practice, and participation, Work Package 3 (WP3) adds a vital layer of analysis: the policy ecosystem in which STEAM education must evolve. Comprising Deliverables D3.1, D3.2, and D3.3, this strand of work offers a strategic view of how policies across Europe currently engage with – or fall short of supporting – the shift from STEM to STEAM. Together, these deliverables trace a clear trajectory: from mapping the current policy landscape (D3.1), through identifying gaps and misalignments (D3.2), to formulating actionable policy recommendations for local, national, and EU levels (D3.3).

Rather than positioning policy as a static background condition, WP3 recognises it as a dynamic force, one that can either enable or constrain innovation in science education. The deliverables draw attention to the disconnects between education and society, between rhetoric and implementation, and between fragmented initiatives and the need for coherent strategies. They also underscore the critical importance of stakeholder engagement and participatory policy development.

The summary synthesis in this Appendix aims to distil the key findings from the three deliverables into a coherent narrative that highlights not only the current state of play but also the opportunities for transformative change. For policymakers, educators, and advocates alike, these insights offer a pathway for embedding STEAM education more fully into the fabric of European policy and practice.

## Policy context for STEAM education (D3.1)

Deliverable D3.1 marks the starting point of Road-STEAMer's policy analysis by mapping the current policy landscape surrounding STEAM education in Europe. Rather than merely cataloguing initiatives, the report takes a critical lens to examine how national and EU-level strategies conceptualise and support interdisciplinary, creative, and socially engaged forms of science education. The goal is not only descriptive but strategic: to understand where STEAM fits into existing policy architectures, and to identify entry points for strengthening its role.

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The analysis draws on a broad selection of policy documents from various European countries, international organisations, and EU institutions. These include national education strategies, digital and innovation plans, as well as broader frameworks like the European Education Area and the European Skills Agenda. By comparing these policies against the conceptual and pedagogical markers of STEAM as developed in earlier Road-STEAMer deliverables, the report surfaces both alignment and tension.

One of the key findings is that while many policies now explicitly reference interdisciplinarity, creativity, and inclusiveness, the integration of the arts into STEM is rarely systematic or deep. Policies often promote "STEM+" approaches, digital innovation, or transversal skills, but few adopt a coherent STEAM lens that places the arts on an equal footing. This gap reflects a deeper challenge: the arts are still frequently treated as complementary rather than constitutive to scientific and technological learning.

Moreover, the report observes a lack of consistency in how policies define key terms such as innovation, creativity, or interdisciplinarity. This semantic vagueness risks reducing STEAM to a policy buzzword, applied inconsistently, measured imprecisely, and supported unevenly across contexts. Even where promising frameworks exist, such as those promoting open schooling or entrepreneurial learning, their connection to STEAM principles is often implicit rather than intentional.

D3.1 also highlights several emerging trends that could serve as leverage points for advancing STEAM policy:

- Digitalisation and the use of technology in education, which offer opportunities to integrate arts-based and design-led approaches.
- The Green and Digital Transitions, which require systems thinking and creativity—hallmarks of STEAM education.
- Increased attention to equity, diversity, and inclusion, although these are often approached separately from innovation and creativity agendas.

Despite these openings, the analysis reveals that policy fragmentation remains a persistent issue. Ministries of education, research, innovation, culture, and labour often operate in silos, producing overlapping or disconnected initiatives. This poses a major barrier to scaling STEAM education, which thrives on integration, not only across disciplines but also across policy domains.

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Importantly, the report points out that top-down support for STEAM must be complemented by bottom-up practice. Effective policies need to be grounded in real classroom conditions and shaped by those who implement them. While some countries have developed pilot programmes or dedicated STEAM centres, the report finds limited evidence of systematic support for teacher professional development, curriculum reform, or institutional change at scale.

### Analysis of policy gaps for STEAM education (D3.2)

Deliverable [D3.2](#) picks up directly from the policy mapping conducted in D3.1 and moves from diagnosis to critique. Its purpose is to systematically identify the missing links, blind spots, and structural weaknesses in the current European policy landscape as it relates to STEAM education. In doing so, it lays the foundation for actionable recommendations by articulating what existing policies fail to address, support, or prioritise.

The methodology for this gap analysis is structured and participatory. First, the team revisited the corpus of policy documents gathered and analysed in D3.1. Then, these policies were assessed against a set of STEAM-relevant criteria developed earlier in the Road-STEAMer project (notably in D2.1, D2.2, D2.3, and D4.1). These criteria reflect key features of high-quality STEAM education, including interdisciplinarity, inclusion, creativity, real-world relevance, and collaboration. Consortium partners and stakeholders were involved in ranking these criteria by importance and applying them in a comparative analysis.

The findings confirm and deepen the concerns raised in D3.1: there is no shortage of policy ambition, but implementation is partial and uneven, and STEAM is rarely treated as a coherent educational approach. Instead, existing policies tend to:

- Emphasise STEM as a strategic economic priority, often decoupled from the cultural and humanistic dimensions that the arts introduce;
- Treat creativity and innovation as generic soft skills, without linking them explicitly to curricular or pedagogical reforms;
- Focus on digital skills and employability without adequate attention to meaning-making, civic engagement, or identity development, which are central to inclusive STEAM education.

Perhaps most critically, the analysis reveals a widespread failure to address structural barriers to participation and equity. While inclusion is often referenced in policy texts, it is seldom operationalised through meaningful measures, such as support for teacher training, inclusive curriculum design, or targeted outreach to marginalised groups. The report highlights that intersectional dimensions (e.g. the combined effects of gender, migration background, and socio-economic status) are almost entirely absent from current policies. This suggests that STEAM's potential to promote social justice remains largely untapped in official strategies.

D3.2 also draws attention to the lack of policy coherence across governance levels. EU-level initiatives, such as Horizon Europe, promote ambitious cross-sectoral and interdisciplinary education goals, yet national systems often remain narrowly discipline-based and exam-driven. This misalignment leads to a policy environment in which innovative practices are supported through temporary projects but not embedded in mainstream structures.

Moreover, policies often fail to recognise the professional development needs of teachers as central to STEAM implementation. While individual projects may offer exemplary training models, there is little evidence of sustained national strategies to prepare and support teachers in interdisciplinary, arts-integrated, or real-world-oriented pedagogy.

Finally, the analysis identifies a disconnect between education policy and broader societal or environmental agendas, such as the Green Deal or digital transition. Where connections are made, they tend to remain rhetorical rather than backed by curriculum reform, resource investment, or systemic change. As such, the opportunity to position STEAM education as a strategic response to Europe's pressing societal challenges is currently underexploited.

### Policy recommendations for STEAM education (D3.3)

Deliverable D3.3 represents the culmination of Road-STEAMer's policy analysis. Drawing on the contextual mapping in D3.1 and the gap analysis in D3.2, it translates insights into a structured set of eight actionable policy recommendations. These recommendations are grounded in a participatory and iterative process involving co-creation workshops, policy dialogues, online consultations, and stakeholder validation. Their objective is to support the development of policies that not only acknowledge STEAM education's potential but enable its effective and equitable implementation across Europe.

The recommendations are clustered into four thematic areas that reflect both policy gaps and strategic opportunities:

- Strengthening the STEAM curriculum at national and EU level

- Enhancing the learning environment and teacher training
- Aligning STEAM with societal and industrial needs
- Promoting equity, diversity, and inclusion in STEAM

Each area is accompanied by two recommendations, with clear distinctions drawn between interventions at the EU, national, and local levels.

**Redefining and supporting the STEAM curriculum:** The first two recommendations advocate for redefining STEAM as a holistic curriculum that balances scientific and artistic literacies and embedding this vision into national educational frameworks. Horizon Europe and EU guidance are seen as critical enablers for this shift, but national ministries must revise frameworks that currently prioritise narrow STEM agendas. This includes the development of open-access, modular teaching resources and adaptable learning materials, grounded in interdisciplinary and real-world contexts.

However, this theme also reveals one of the main challenges: despite being rated as highly important, curriculum reform is seen as risky and difficult to implement, especially where national systems are resistant to change or operate under highly centralised structures.

**Empowering teachers and learning environments:** Recognising the central role of teachers, the next two recommendations call for mandatory STEAM training at both pre-service and in-service levels, alongside more opportunities for professional development. Importantly, these recommendations emphasise collaborative learning environments, including partnerships between schools and external stakeholders, as essential to STEAM's relational and project-based ethos.

Participants underscored the need for "train-the-trainer" models and national training institutes to adapt EU-level materials to local contexts. There was also strong support for open schooling networks, funded through EU clusters, to promote peer learning and transfer of best practices across Europe.

**Connecting STEAM to society and industry:** To ensure that STEAM remains relevant to contemporary challenges, D3.3 advances recommendations that explicitly align STEAM education with societal impact and labour market demands. It proposes integrating STEAM into EU strategic agendas, such as the European Green Deal, and calls for education-industry partnerships that foster student engagement with real-world problems.

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Participants advocated for legislative safeguards to prevent private sector overreach, while also encouraging co-creation of flexible, lifelong learning pathways, particularly for underrepresented groups. These partnerships should be governed by equity principles and support the development of skills at the intersection of creativity, technology, and sustainability.

**Advancing inclusion through intersectional policy design:** The final thematic area focuses on inclusion, pushing beyond the often singular emphasis on gender to embrace a more intersectional approach. This includes acknowledging how ethnicity, income, disability, and other factors intersect to shape educational disadvantage. Policies must move from vague commitments to concrete interventions, such as targeted mentorship programmes, scholarships, and adaptive curricula that meet the needs of diverse learners.

Yet this theme also revealed a paradox: while inclusion was widely seen as morally and educationally essential, recommendations in this area were rated lowest in terms of perceived implementation likelihood. This points to persistent tensions between equity rhetoric and systemic inertia, and calls for renewed advocacy to elevate inclusion as a strategic policy goal, not a peripheral concern.

A key strength of D3.3 lies in its methodology. The recommendations are not abstract or top-down; they were shaped through direct interaction with educators, researchers, policymakers, students, and community stakeholders. Events such as the co-creation workshop in Athens and the interactive Miro board sessions helped surface divergent perspectives, test feasibility, and refine proposals. This participatory process lent legitimacy to the recommendations and ensured that they reflect lived experience and professional realities.

To support uptake, the report also includes a preliminary risk analysis, highlighting political, cultural, and structural barriers to implementation. This candid assessment enhances the credibility of the recommendations and helps stakeholders plan for realistic next steps.

## Conclusion: Advancing STEAM through coherent and inclusive policymaking

The Road-STEAMer project's policy-focused deliverables summarised above (D3.1, D3.2, and D3.3) offer a coherent and forward-looking narrative that moves from analysis to action. Collectively, they illuminate not only where European education systems stand in relation to STEAM, but also what is needed to bridge the gap between aspiration and implementation.

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D3.1 maps the current policy landscape and finds growing recognition of interdisciplinarity, creativity, and digital innovation, but also reveals that the arts are often marginalised, and inclusion remains underdeveloped. D3.2 sharpens this picture by identifying critical policy gaps, especially in the areas of equity, curriculum coherence, teacher support, and alignment with broader societal agendas. It calls attention to the disconnect between policy discourse and structural change. D3.3 then builds on this foundation to formulate targeted, actionable recommendations that speak directly to EU, national, and local policy levels, with a strong emphasis on curriculum reform, teacher empowerment, strategic partnerships, and intersectional inclusion.

Across all three deliverables, several key themes emerge:

- STEAM must be positioned as a strategic and systemic innovation, not an optional enrichment to traditional STEM.
- Policy coherence across levels and sectors is essential for meaningful and sustained change.
- Equity and inclusion must be embedded in both design and implementation, with attention to the complex realities of underrepresented learners.
- Teachers are the linchpin of any STEAM strategy and must be supported not only through training but through professional agency and peer networks.
- Societal relevance and participatory governance are essential: STEAM must connect education with the real-world challenges Europe faces, from climate change to digital transformation.

Crucially, these conclusions are not theoretical. They are rooted in extensive stakeholder dialogue and reflect the collective expertise of educators, researchers, policymakers, and community actors across Europe. The process through which the recommendations were developed is itself a model of inclusive and participatory policy design – one that invites shared ownership and joint responsibility for STEAM's future.

For policymakers, this synthesis underscores a simple but powerful message: STEAM education has the potential to transform how we teach, learn, and engage with science and society—but only if we create the conditions for it to thrive. That means investing in people, aligning systems, and daring to reimagine the role of education in a rapidly changing world.

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# Appendix C: STEAM context, concepts and conditions

## Introduction

At the foundations of the present Roadmap lies a comprehensive analysis of STEAM concepts, contexts and conditions. The four Road-STEAMer deliverables synthesised in this Appendix (D2.1, D2.2, D4.1, and D2.3) form a coherent intellectual backbone of the project's vision, each contributing a vital layer to the understanding of STEAM's context, conceptual foundations, conditions for practical implementation and system-level requirements. Together, these four deliverables create a knowledge architecture that is both research-grounded and practice-aware. D2.1 maps the broader socio-economic landscape and needs that call for a STEAM approach, shedding light on participation gaps, industry demands, and societal expectations for science education. D2.2 then develops a conceptual framework that draws from diverse academic traditions to articulate the meanings, dimensions, and pedagogical potentials of STEAM. D4.1 complements this with a robust research framework, defining criteria for mapping and analysing STEAM practices and offering a structured lens through which real-world applications can be understood and evaluated. Finally, D2.3 consolidates previous insights to offer a detailed analysis of the conditions and requirements for integrating STEAM in everyday school life, from curriculum design to teacher agency and school leadership. Individually, each deliverable offers depth in its own focus area. Collectively, they contribute to a comprehensive picture of STEAM in European education as both a response to contemporary challenges and an innovation in need of thoughtful implementation.

## Socio-economic context and relevant needs for STEAM education (D2.1)

Deliverable D2.1 sets the stage for the Road-STEAMer project by providing a deep exploration of the socio-economic landscape in which STEAM education must be conceptualised and implemented. It identifies the pressing societal challenges, systemic barriers, and educational inequalities that make a STEAM approach not merely desirable but necessary. Through literature reviews, secondary data analysis, and co-creation workshops, this report constructs a compelling rationale for why Europe must broaden its understanding of science education and reimagine it through the integrated lens of STEAM.

At the heart of D2.1 is the recognition that participation in STEM disciplines is highly stratified by socio-economic status, gender, and cultural background. Rather than framing this as a

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linear “leaky pipeline” issue, where certain groups simply drop out, the report suggests a more nuanced metaphor: a “hostile obstacle course” that shifts responsibility from the individual to the broader system. The barriers are not just technical or academic; they are cultural, institutional, and perceptual. For example, science is often perceived as difficult, abstract, and disconnected from students’ lives—especially for those from marginalised communities.

STEAM offers a transformative potential in this context. The integration of the arts is seen not as a decorative addition but as a means of making science more relatable, creative, and inclusive. Arts-based methods can help students connect abstract concepts to real-world experiences, support emotional engagement, and facilitate identity formation—particularly for those who might not see themselves as “science people.” The inclusion of arts also responds to industry needs: employers increasingly value “soft skills” such as creativity, collaboration, intercultural competence, and communication, alongside technical proficiency. STEAM, therefore, aligns educational practice more closely with both societal and labour market needs.

Crucially, the report emphasises that diversity in STEAM is not only a question of representation but of justice. Cultural stereotypes, lack of role models, and systemic inequalities prevent many students—especially girls, ethnic minorities, and those from lower socio-economic backgrounds—from engaging meaningfully with science education. STEAM can address these barriers by promoting epistemic justice, offering diverse pathways into science, and reconfiguring what counts as valid knowledge and who is seen as a legitimate knower.

Four key areas of societal need are explored, each linked to barriers in STEM and potential benefits of STEAM:

- The need for more scientists, which STEAM supports by making science more engaging, emotional, and accessible.
- The alignment of education with industry and societal needs, with STEAM offering multidisciplinary, real-world learning opportunities.
- The promotion of diversity and inclusion, through culturally responsive pedagogy and the arts’ appeal to a wider range of learners.
- The enhancement of science literacy for all, by lowering affective barriers and making science more connected to everyday life.

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These needs are mapped to concrete recommendations: integrating arts meaningfully into curricula, investing in teacher-friendly STEAM materials, showcasing diverse role models, and expanding research into what works, for whom, and under which conditions. Importantly, the report stresses that no single intervention will suffice. The reality is complex, multi-layered, and context-dependent, requiring systemic thinking and intersectional approaches.

## Conceptual framework for STEAM education (D2.2)

Deliverable D2.2 builds upon the socio-economic rationale established in D2.1 by developing a robust conceptual framework that defines what STEAM education means in the context of the Road-STEAMer project. This is not a superficial or instrumental definition. Instead, it offers a nuanced and theoretically grounded synthesis of diverse traditions of thought, aiming to support both reflective policy development and practical design of STEAM learning experiences.

At its core, the Road-STEAMer conceptual framework is relational: it does not see STEAM as a fixed or uniform model but as a field of interconnected practices, principles, and pedagogical possibilities. The report draws on an extensive thematic analysis of theoretical and practical literature, combined with a co-creation workshop involving both academics and practitioners. It identifies four key clusters of approaches that shape how STEAM can be understood and enacted:

- **Experiential, real-world interaction approaches**, which emphasise hands-on, authentic engagement with real-world problems and situations.
- **Human psychological and cognitive approaches**, focusing on individual learners' thinking, motivation, and meaning-making.
- **Social, spatial and material interconnectivity approaches**, which explore the interrelation between people, spaces, technologies, and material artefacts.
- **Cultural and equity approaches**, which position STEAM as a means to address diversity, inclusion, and social justice in education.

Rather than choosing one of these as the "correct" model, the framework acknowledges the value of multiple overlapping perspectives. This inclusive stance is key to making STEAM education responsive to different contexts, learners, and institutional settings across Europe.

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Importantly, the report does not remain abstract. It links the conceptual framework directly to the criteria developed in Deliverable D4.1, which guide the mapping and analysis of real-world STEAM practices (see next section of the present Appendix).

By linking theory to practice in this way, D2.2 helps bridge the gap between pedagogical ideals and educational realities. It encourages stakeholders to think of STEAM not merely as a cross-curricular programme, but as a transformational approach to education—one that invites new ways of thinking, creating, collaborating, and engaging with the world.

This conceptual openness is a strength. It allows the framework to accommodate different national curricula, school traditions, and local priorities. At the same time, it offers clear orienting principles for designing and evaluating STEAM activities. Whether the focus is on a high-tech fabrication lab, a community-based design project, or a classroom exploring climate change through art and science, the framework provides a shared vocabulary and reference point.

For policymakers, the message is clear: effective support for STEAM education requires more than funding discrete projects or integrating isolated modules. It entails cultivating enabling ecosystems, where curriculum, pedagogy, infrastructure, and institutional culture converge around the values of creativity, equity, and interdisciplinary learning.

### Research framework for mapping and analysing STEAM practices (D4.1)

Deliverable D4.1 provides the operational backbone for the empirical work of the Road-STEAMer project. Where D2.1 diagnoses the socio-economic imperatives for STEAM and D2.2 constructs a conceptual scaffold, D4.1 establishes a research framework to systematically identify, map, and analyse STEAM practices across Europe. It does so by proposing a set of analytical criteria that are both theoretically informed and practically applicable, ensuring coherence between the project's conceptual ambitions and its field-level investigations.

The core contribution of D4.1 lies in its development of six interrelated criteria for analysing STEAM educational practices. These criteria were distilled from a systematic literature review and refined through a participatory co-creation workshop. Together, they provide a flexible yet rigorous lens for assessing the quality and character of STEAM activities. The six criteria are:

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- **Collaboration** – examining the presence and quality of cooperation across disciplines, among students, teachers, and external partners.
- **Disciplinary inter-relationships** – identifying the degree and nature of integration between scientific, technological, engineering, mathematical and artistic domains.
- **Thinking–making–doing** – exploring the link between cognitive engagement and hands-on activity, highlighting how knowledge is enacted.
- **Creativity** – assessing the extent to which a practice promotes original, imaginative, and meaningful work, individually or collectively.
- **Real-world connection** – investigating how learning activities relate to authentic problems, societal challenges, or community contexts.
- **Inclusion / Personalisation / Empowerment** – focusing on how practices adapt to learner diversity, promote participation, and enable students to develop a sense of agency.

Crucially, D4.1 treats **equity** as an underlying value rather than a stand-alone dimension. Equity, in this context, is not limited to access or representation but is embedded in how practices are designed, implemented, and assessed. It influences everything from the choice of topics and materials to the role students play in shaping their learning.

These criteria are not meant to act as rigid evaluative checklists. Instead, they function as heuristic tools that guide both the identification of promising practices and the reflection on their potential impacts. Importantly, the framework does not assume that all practices must score equally across all six dimensions. Rather, it recognises the heterogeneity of STEAM in practice and seeks to illuminate the distinctive configurations of each example.

In methodological terms, the research framework developed in D4.1 balances academic rigour with practical usability. It is grounded in literature from education, learning sciences, and design research, but remains accessible to practitioners, policymakers, and project partners. The framework is designed to be applied flexibly across diverse settings—formal and informal, urban and rural, high-tech and low-resource—making it suitable for the wide variety of STEAM practices encountered across Europe.

Furthermore, D4.1 plays a pivotal role in bridging conceptual clarity and empirical mapping. It is explicitly linked to the conceptual framework in D2.2, ensuring that the values and principles elaborated there are reflected in how practices are identified and analysed. This coherence strengthens the project's capacity to generate meaningful insights—not just about whether STEAM practices exist, but how and why they work, for whom, and under what conditions.

For policymakers, the value of D4.1 lies in its systematising power. It provides a structured approach to evaluating STEAM practices that goes beyond anecdotal success stories. It offers criteria that can inform funding decisions, curriculum reforms, teacher training programmes, and institutional innovations. By foregrounding collaboration, real-world relevance, and learner empowerment, it shifts the focus from disciplinary coverage to educational quality and impact.

### Conditions and requirements for the integration of STEAM in education (D2.3)

Deliverable D2.3 represents the culmination of the foundational work carried out mainly in Work Package 2 (and partially in WP4, cf. D4.1) of the Road-STEAMer project. Building directly upon the socio-economic diagnosis (D2.1), the conceptual foundation (D2.2), and the research framework (D4.1), this deliverable provides a comprehensive analysis of the conditions, challenges, and enabling factors for the effective and sustainable integration of STEAM practices into everyday educational settings across Europe.

The report approaches STEAM not as an isolated educational trend, but as a complex, systemic innovation requiring transformation at multiple levels of the education system. Drawing from educational change literature, workshop dialogues with educators, stakeholder engagement, and three detailed questionnaire instruments, D2.3 synthesises academic theory and practitioner insight into a grounded vision of what it takes to make STEAM work in real schools.

The analysis begins by positioning STEAM as a case of educational innovation whose adoption depends on a constellation of interacting factors—ranging from individual teacher beliefs and skills to systemic structures and policy frameworks. Drawing on diffusion of innovation theory and implementation science, the report identifies key enablers and obstacles at the individual, school, and systemic levels. It also distinguishes between contextual factors (e.g. policy, culture, infrastructure) and innovation-inherent factors (e.g. perceived value, ease of implementation, compatibility with current practice).

Importantly, the report frames STEAM not simply as the integration of arts into STEM, but as a pedagogical shift toward relational, real-world, inclusive learning. As such, its adoption cannot be reduced to a technical matter of curriculum design or materials provision. It

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requires cultural and structural change—including new roles for teachers, new expectations for leadership, and new forms of assessment and accountability.

Four main areas of conditions and requirements are examined in depth:

**1. Curriculum integration:** The report finds strong agreement on the pedagogical value of STEAM, especially its potential to foster creativity, motivation, and problem-solving. However, the challenge lies in integrating these practices meaningfully within existing curricular structures. Respondents overwhelmingly favoured STEAM as an integrated approach across the curriculum, rather than a separate subject. Yet, interdisciplinary or transdisciplinary collaboration remains difficult in systems dominated by subject silos and rigid timetables. Assessment practices also tend to lag behind, often failing to capture the learning outcomes most associated with STEAM (e.g. collaboration, design thinking, personal expression).

Despite these challenges, elements such as hands-on learning, real-world problem engagement, and student ownership were seen as relatively feasible entry points for STEAM implementation. The report also highlights the necessity of rethinking not only content but also the conditions for learning—emphasising playfulness, experimentation, and multiple pathways to knowledge as integral to STEAM.

**2. Teacher roles and agency:** Teachers are rightly seen as pivotal to any educational innovation, but D2.3 moves beyond a focus on individual competence to explore how teacher agency—the ability to act purposefully and influence change—is shaped by broader institutional and cultural conditions. Workshops and survey data reveal high levels of teacher motivation and belief in STEAM, but also frustration with structural barriers, including lack of autonomy, limited collaboration time, and insufficient professional development.

The report calls for supporting teachers not only as implementers but as co-designers and leaders of innovation. This includes giving teachers more freedom to adapt practices, recognising their expertise, and building horizontal networks for knowledge exchange. Equally, the shift from instructor to facilitator of inquiry and creativity requires investment in pedagogical transformation and trust in teacher professionalism.

**3. School leadership and organisational culture:** Effective integration of STEAM depends heavily on school-level leadership and culture. D2.3 shows that supportive school leadership – particularly that which fosters distributed leadership, embraces experimentation, and plans strategically for innovation – is crucial. Yet, many participants report that their schools remain dominated by risk-averse, hierarchical structures and time constraints that leave little space for cross-curricular collaboration.

The report identifies a need to rethink school organisation as an enabling ecosystem, with flexible timetables, collaborative planning structures, and shared pedagogical vision. A recurring insight is that STEAM-friendly environments require intentional cultural work—not just logistical adjustments. This includes valuing all disciplines equally, encouraging interdisciplinary dialogue, and framing failure as a learning opportunity.

**4. Professional development and support:** Teachers consistently cited the need for high-quality, ongoing professional development tailored to the challenges of interdisciplinary, arts-integrated, and real-world-oriented teaching. D2.3 calls for professional development that is collaborative, practice-based, and sensitive to local context. Importantly, it must also be systemic, linked to leadership practices, school strategy, and policy support.

Participants also expressed a desire for more structured opportunities for peer exchange, co-teaching, and interdisciplinary collaboration. Support should extend beyond training to include access to resources, materials, mentorship, and communities of practice.

The report closes with a forward-looking analysis of the opportunities and future pathways that could catalyse STEAM integration. These include:

- Synergies with open schooling and open science, which offer real-world relevance and community engagement.
- Connections with digital fabrication, design thinking, and playful learning, which align well with STEAM principles.
- Alignment with European policy priorities such as the Green Deal, digital transition, and equity agendas.

D2.3 thus frames STEAM not as a niche pedagogical trend but as a strategic response to 21st-century educational and societal needs. However, it also makes clear that its potential will only be realised if conditions are created to support long-term, systemic innovation, rooted in practice but enabled by policy.

## Conclusion: Towards a coherent vision for STEAM education in Europe

Taken together, the Road-STEAMer deliverables summarised above (D2.1, D2.2, D4.1, and D2.3) offer a comprehensive and multi-layered foundation for advancing STEAM education

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as a key driver of inclusive, future-oriented learning in Europe. Each deliverable contributes a distinct but interconnected perspective (contextual, conceptual, methodological, and practical) towards understanding what STEAM can offer and what it requires to take root meaningfully in schools.

The socio-economic analysis in D2.1 establishes a compelling case for STEAM as a response to systemic inequities, underrepresentation, and shifting labour market demands. It situates STEAM as not merely a pedagogical innovation but a tool for equity, engagement, and relevance. D2.2 elaborates a rich conceptual framework that embraces multiple traditions and positions relationality, interdisciplinarity, and creativity at the heart of the STEAM vision. It offers not a fixed model but a flexible architecture to support diverse, localised enactments of STEAM. D4.1 operationalises this vision through a clear and adaptable research framework, providing analytical criteria that bridge theory and practice. These criteria allow for consistent mapping and evaluation of STEAM practices while remaining sensitive to context. Finally, D2.3 synthesises these insights into a detailed examination of the real-world conditions and requirements for implementation. It identifies the opportunities and barriers across curriculum, teacher agency, school leadership, and systemic support, and shows that successful STEAM adoption hinges not just on individual innovation but on enabling educational ecosystems.

For policymakers, this synthesis sends a clear message: STEAM is not a “plug-and-play” programme, but a complex and promising innovation that demands systemic thinking, long-term commitment, and trust in educators’ professional capacities. Its potential lies in its power to connect learning with lived experience, disciplinary knowledge with creativity, and schools with society. To realise this potential, we must invest not only in resources, but in cultural change, toward more open, inclusive, and connected forms of education.

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## Appendix D: AI and education

The crucial ethical concerns for the integration of AI in education highlighted in existing studies include data privacy, algorithmic bias, potential discrimination, transparency, accountability and human interference, equity, a new digital divide and the potential exacerbation of educational inequalities, fairness, and respecting human rights (Sharma et al 2024; *Zawacki-Richter, et al. 2019)*. To address these challenges, current studies have focused on the need for critical reflection and comprehensive understanding of the challenges and risks of AI, the need for infrastructural and organisational changes and a strategic approach for AI design and implementation. Strong connections to pedagogical perspectives and approaches are emphasised in all education levels for the successful adaptation and integration of AI technologies in education (Zawacki-Richter, et al. 2019; Şen Demir & Demir, 2024; Babenko & Bezuglova, 2025).

### EU and International Initiatives

These concerns are echoed in strategies and policies of EU and International bodies aiming at addressing the challenges while ensuring the benefits for the individuals, society, and the economy.

In the framework of ***UNICEF's Generation AI*** initiative, in cooperation with the World Economic Forum, UC Berkeley Center for Human Rights and others, a Memorandum of Artificial Intelligence and Child Rights was published (2019), placing the children's rights in the centre of the discussion and providing policy guidance on AI for children (https://www.unicef.org/innovation/reports/memoAIchildrights, https://www.unicef.org/globalinsight/featured-projects/ai-children, https://www.unicef.org/globalinsight/reports/policy-guidance-ai-children) (Memorandum on Artificial Intelligence and Child Rights, UC Berkeley Human Rights Center Research Team, Artificial Intelligence and Child Rights Working Group, 2019,).

Similarly, **UNESCO** published a report with policy recommendations on AI in Education (Division for Policies and Lifelong Learning Systems, UNESCO's Education. (2019). Artificial Intelligence in Education: Challenges and Opportunities for Sustainable Development (Working Paper No. 7; Working Papers on Education Policy, p. 48). UNESCO.), while in 2021 it published an AI and Education guidance for policy makers (2021), and in 2024 it published an AI competency framework for students and an AI competency framework for teachers .

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The ***OECD Future of Education and Skills 2030*** project conducted a comprehensive curriculum analysis. The report (OECD, 2021) summarised existing trends, challenges and practices and emphasised the critical role of integrating values and attitudes -beyond knowledge and skills- into educational curricula to prepare students for an increasingly complex world. The key values and attitudes emphasised were respect, equity and inclusion for the promotion of fairness, social justice, and inclusivity in learning environments to ensure equal opportunities for all, global and environmental awareness, appreciation for cultural diversity, understanding of global challenges, collaboration and empathy for diverse viewpoints, critical thinking, and flexibility to navigate a rapidly changing world. The report argues that explicitly embedding values into curricula can help students develop the social and emotional skills needed for both individual success and societal well-being.

The ***European Commission*** also published Ethical Guidelines on the Use of Artificial Intelligence and data to support teachers and students in their teaching and learning, and administrative tasks in educational settings (2022). The guidelines were part of the Digital Education Action Plan (2021-2027)and emphasised an education policy addressing AI's ethical use, human intervention and supervision, diversity, transparency, fairness, equity, and social and environmental prosperity (Digital Education Action Plan – Action 6).

The ***European AI Office*** developed within the European Commission,  supports the development of AI systems in fields such as Sciences, Robotics, and Health Care. Its key role is to support the implementation of the ***AI Act***, the first legal framework on AI world-wide signed by the member states. Core concepts of EU's approach to AI design and implementation are trust, safety, the fundamental rights of people, and the societal and economic benefits.

***Europe's Digital Decade*** policy focuses on empowering citizens and businesses through a "human-centric, sustainable vision for digital society". To this end, "Ensuring everyone can participate in digital opportunities, and no one is left behind" is among the principal objectives for the digital transformation of Europe for the benefit of all people.

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## Appendix E: Funding opportunities specifically for AI and education

Effective management of resources and coordination of investments are considered critical components of AI excellence, with programmes such as ***Horizon Europe*** and ***Digital Europe*** investing €1 billion per year in AI (https://digital-strategy.ec.europa.eu/en/policies/european-approach-artificial-intelligence). EU funding tools are already in place, such as Horizon, and Erasmus+ which have already funded projects on STEAM (and AI particularly) in education, teaching, and learning.

### 1) Erasmus+ Programme

***Forward-Looking Projects Call 2025***: Supports transnational projects aiming to develop and assess innovative approaches in digital education (https://education.ec.europa.eu/news/funding-available-for-forward-looking-projects-in-digital-education). Key topics include:

- Artificial Intelligence Systems in Education and Training: Focuses on fostering organizational readiness for the ethical and effective adoption of AI technologies in educational settings. Particularly *Topic 7: Digital education: Ethical and effective use of generative Artificial Intelligence systems in education and training* (ERASMUS-EDU-2025-PI-FORWARD-DIGITAL-AI, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/ERASMUS-EDU-2025-PI-FORWARD-DIGITAL-AI)
- Assessment of Digital Skills and Competences: Aims to explore and develop robust assessment methodologies for digital skills across various educational contexts. Particularly Topic 6: Digital education: Assessment of digital skills and competences (ERASMUS-EDU-2025-PI-FORWARD-DIGITAL-SC, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/ERASMUS-EDU-2025-PI-FORWARD-DIGITAL-SC)
- Innovative Data Collection and Exchange Approaches: Seeks to develop ethical and privacy-centred data collection and analysis methods to inform decision-making in education. Particularly Topic 8: Digital education: Innovative data collection and exchange approaches in primary, secondary education (including vocational education and training) for data-informed decision-making (ERASMUS-EDU-2025-PI-FORWARD-DIGITAL-DM,

https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/ERASMUS-EDU-2025-PI-FORWARD-DIGITAL-DM)

**2) Digital Europe Programme (DIGITAL)**

The programme (https://digital-strategy.ec.europa.eu/en/activities/digital-programme) focuses on enhancing Europe's digital capacities, including:

- Advanced Digital Skills: Funding is available for projects that aim to develop advanced digital competencies, crucial for the effective integration of AI in education.
- Artificial Intelligence: Supports the development and deployment of AI technologies across various sectors, including education.

**3) Horizon Europe Programme**

As the EU's key funding programme for research and innovation, Horizon Europe addresses technological and societal aspects of AI development. ***AI in Science*** funds projects that integrate AI to advance scientific research and innovation, which can be leveraged to enhance AI education within the STEAM fields (https://rea.ec.europa.eu/research-and-artificial-intelligence_en, https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/artificial-intelligence-ai-science_en).

**4) InvestAI**

In February 2025, the ***InvestAI*** initiative was launched by the EU to mobilize €200 billion (https://ec.europa.eu/commission/presscorner/detail/en/ip_25_467). It focuses on the development of a large AI infrastructure and AI gigafactories. This initiative includes financial support  through Horizon Europe and the Digital Europe programme dedicated to generative AI and “accompanying initiatives to strengthen the EU's generative AI talent pool through education, training, skilling and reskilling activities”, as well as the ***GenAI4EU*** initiative, which aims to support the development of novel use cases and emerging applications in Europe's industrial ecosystems, as well as the public sector. Application areas include robotics, health, biotech, manufacturing, mobility, climate and virtual worlds.

These funding opportunities and policies are designed to support projects that aim to integrate AI into education, enhance digital skills, and promote ethical use of AI within the STEAM framework.

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