WP5 Synthesis of the STEAM roadmap for Science Education in Horizon Europe

Deliverable 5.2 STEAM roadmap for Science Education in Horizon Europe v2

ROADSTEAMER

ROADSTEAMER

Deliverable 5.2 - STEAM roadmap for Science Education in Horizon Europe v2

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List of Abbreviations

Abbreviation	Description
AI	Artificial Intelligence
DEAP	European Union's Digital Education Action Plan (2021-2027)
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
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

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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
STEM	Science, Technology, Engineering, Mathematics
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
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
UNESCO	United Nations Educational, Scientific and Cultural Organization
ZSI	Zentrum für Soziale Innovation

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0.1	14/02/25	Sabrina Bresciani	PO	Initial draft (D5.1)
0.2	16/03/25	Sabrina Bresciani, Sunith Joseph, Yuhao Jiang Annalisa Addis, Elena Silvestrini Elisabeth Unterfrauner, Claudia Magdalena Fabian Pavlos Koulouris Lindsay Hetherington, Kerry Chappel Iro Voulgari Menelaos Sotiriou Stephanos Cherouvis	PO, LC, ZSI, EA, UoE UoM SV EC	Second version (D5.1)
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1.1	15/07/25	Sabrina Bresciani, Sunith Joseph Elena Silvestrini	PO LC	Revision and first draft of new sections (D5.2)
1.2	30/07/25	Pavlous Koulouris Sophie Juillard Francesca Rizzo Francesco Mureddu, Annalisa Addis Luca Laszlo Petra Van Haren	EA TR PO LC ESHA	Reviewers' comments (D5.2)
1.3	16/08/25	Sabrina Bresciani Sunit Joseph Elena Silvestrini	PO PO LC	Incorporation of reviewers' comments and final draft (D5.2)
2.0	28/08/25	Elena Silvestrini, Annalisa Addis, Marta Anducas	LC	Revision, final formatting and pdf submission

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Abstract

This report constitutes Deliverable 5.2 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 second version of the elaboration of the roadmap, aimed at proposing strategies and concrete actions and specific recommendations 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 Connect).

This document builds on the first version of the roadmap published as D5.1 on 30th April 2025, and further refines it based on the feedback collected in structured workshops, dialogues, through the online platform and presentations. In comparison to the first version of the roadmap in D5.1, this deliverable contains a presentation of the feedback received, implementation of such feedback, as well as a discussion of feasibility and possible impacts of the strategy, which are outlined in chapter 4. The roadmap is summarized in an interactive visual, which is an updated version of the interactive visual proposed in D5.1. In addition, a second visual format with the same content is also provided as a response to the feedback received. The revised roadmap proposes a “Mission Education” to be introduced in Horizon Europe and subsequent FP10, for a systemic change of the education system to be: skills-focused, transdisciplinary inclusive, enabled by digital technologies and AI. The proposed long-term research action of the “Mission Education” should coordinate with the European STEM executive panel and orchestrate a series of EU-funded research actions and projects along four key priority areas:

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

2) *Enhancing teacher training and the learning environment* (prioritize STEAM training for educators and schools/university leaders; foster inclusive and supportive learning environments harnessing AI and digital tools);

3) *Aligning STEAM education and career design with societal and industrial needs* (Develop STEAM career design and integrated learning pathways; encouraging agile partnerships with organizations to address industrial and societal needs);

4) *Promoting equity with transdisciplinary, effective & inclusive STEAM education paradigms* (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 the second and final 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, which are refined based on the feedback received from the presentation of the first version (April to July 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 future-oriented 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.

Through this process, a first version of the roadmap was developed with the aim of gathering feedback. The Road-STEAMer roadmap has been presented at a high-level roundtable with the European Commission, as well as with other key institutions and national representatives. It was also shared during a co-design workshop with projects funded under the same call. In addition, it has received input from stakeholders during three workshops

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and one dialogue session. The roadmap was further presented at the final event of the three projects, *"STEAM Atlas of Roadmaps,"* held at the European Commission on 2 July 2025, where all three projects (Road-STEAMer, SEER and SENSE) showcased their roadmaps.

The results are synthesized in a roadmap provided in a visual and interactive version in a matrix (Fig. 1) and a timeline (Fig.2) format, as well as a textual version with all actions outlined in Section 2 of this deliverable. The feedback collected and changes made compared to the first version are outlined in Section 3, together with an exploration of feasibility and impact.

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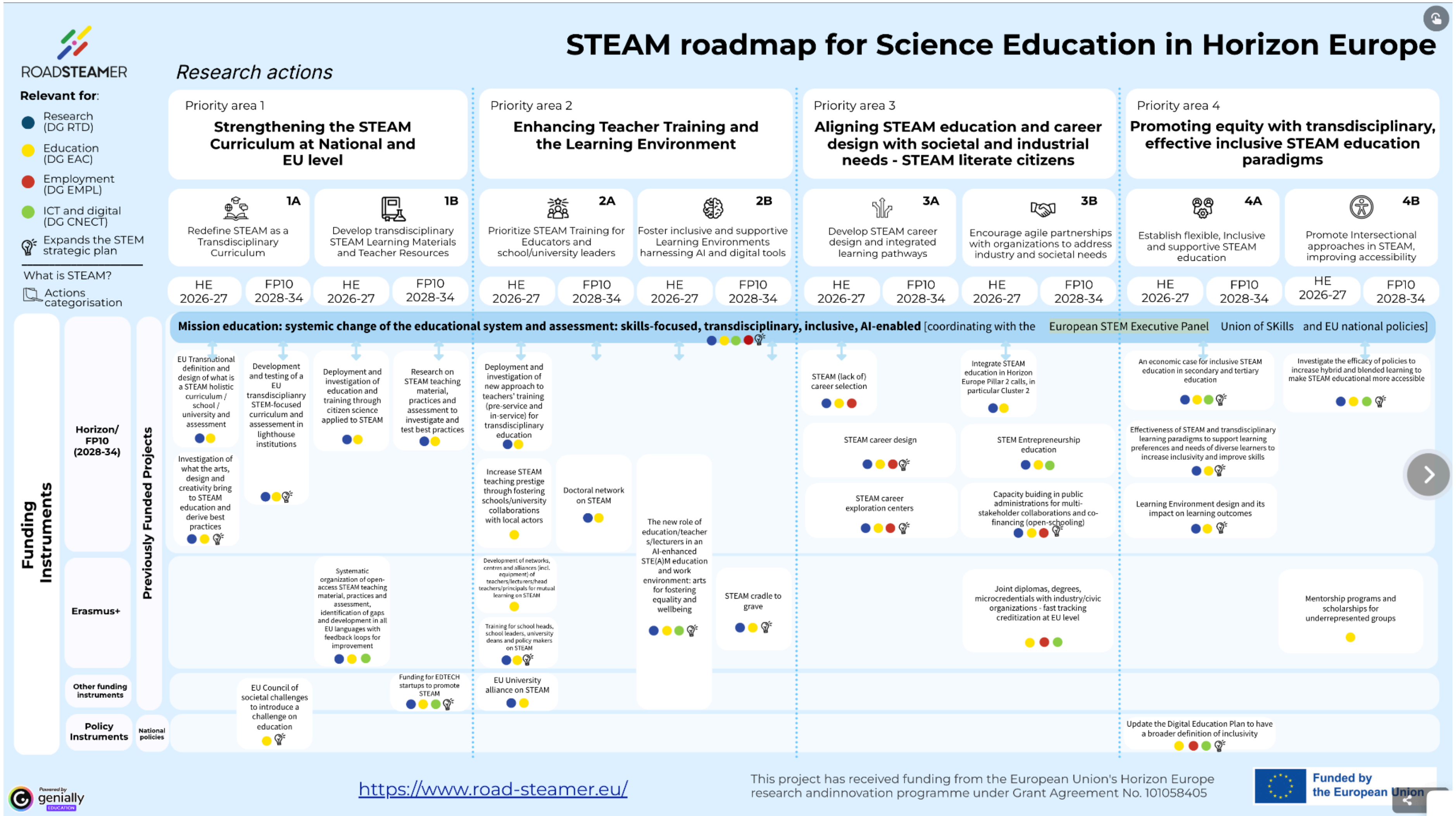

Figure 1: Screenshot of the interactive version of the roadmap (matrix format)

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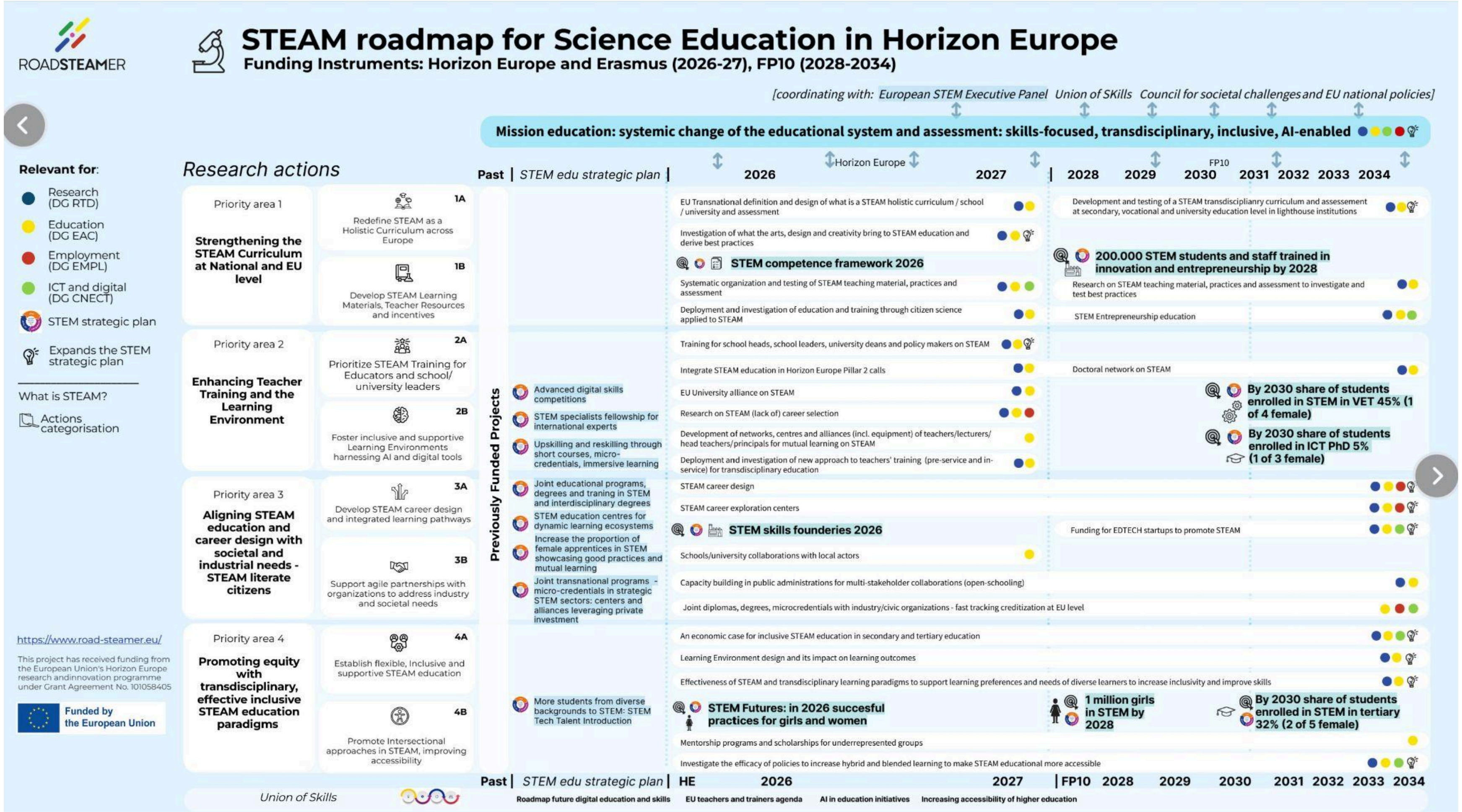

Figure 2: Screenshot of the interactive version of the roadmap (timeline format)

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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.). Based on the feedback received in the testing phase, the examples in each of the 30 proposed actions are classified depending on the educational level and type of initiatives. In addition, based on the results of the testing, the second version of the roadmap is offered also in the format of a timeline (Fig. 2), which includes references to the milestones and actions of both the Union of Skills and the STEM Education Strategic Plan.

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

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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 alignes with the JRC Science for Policy Brief "STEM 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 into three main chapters, followed by Conclusions and an Appendix.

Chapter 1 presents a synthesis of the methodologies used to develop the roadmap. It largely mirrors the content of Deliverable D5.1 (the first version of the roadmap) and is included in full. Minor updates have been made to Section 1.4 to incorporate additional STEAM-related funded projects.

- **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.

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- **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.
- **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 updated version of the roadmap**:

- **Section 2.1** provides a visual map of the roadmap in the form of an interactive matrix, as well as in the format of a timeline, 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.

In **Chapter 3** the feedback received and changes implemented are described, with a discussion on feasibility and impact.

- In **Section 3.1** the testing of the roadmap specifically for feasibility is reported, outlining the improvements implemented
- **Section 3.2** provides a discussion of the envisioned impact.

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; F: Testing methodology. Compared to D5.1 (Roadmap Version 1), Appendix A has been updated, and a new Appendix F has been added, providing detailed information on the testing methodology described in Chapter 3.

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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 3) provides insights into the variety of theoretical and methodological paradigms utilized for STEAM studies.

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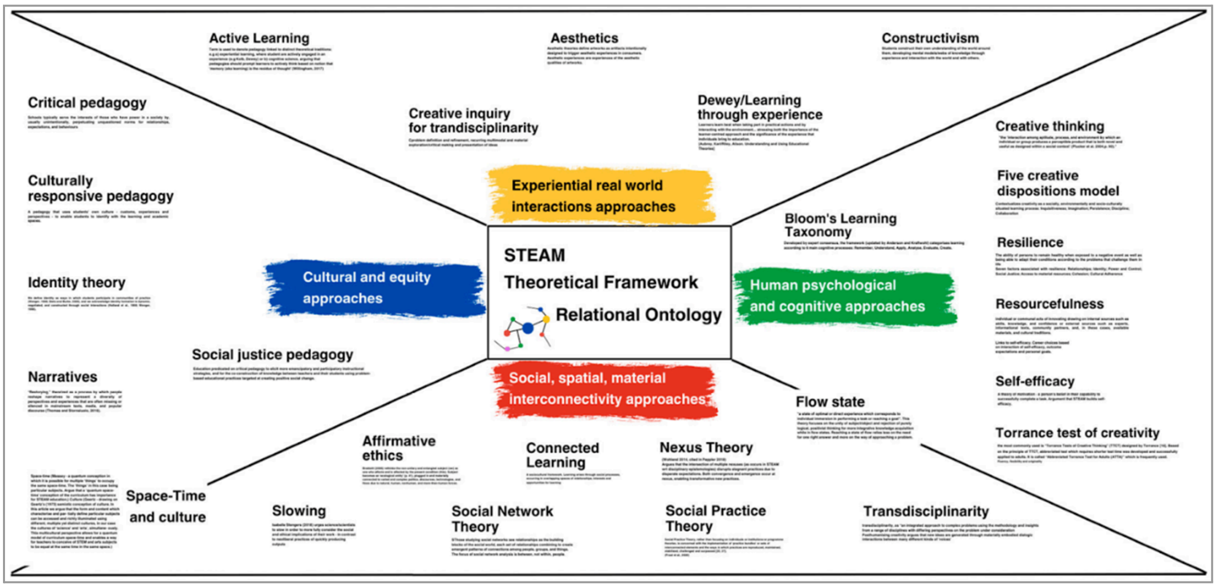

Figure 3: The STEAM theoretical framework relations ontology developed in this project (Source: Chappell & Hetherington, 2023; Chappell et al., in review)

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 4.

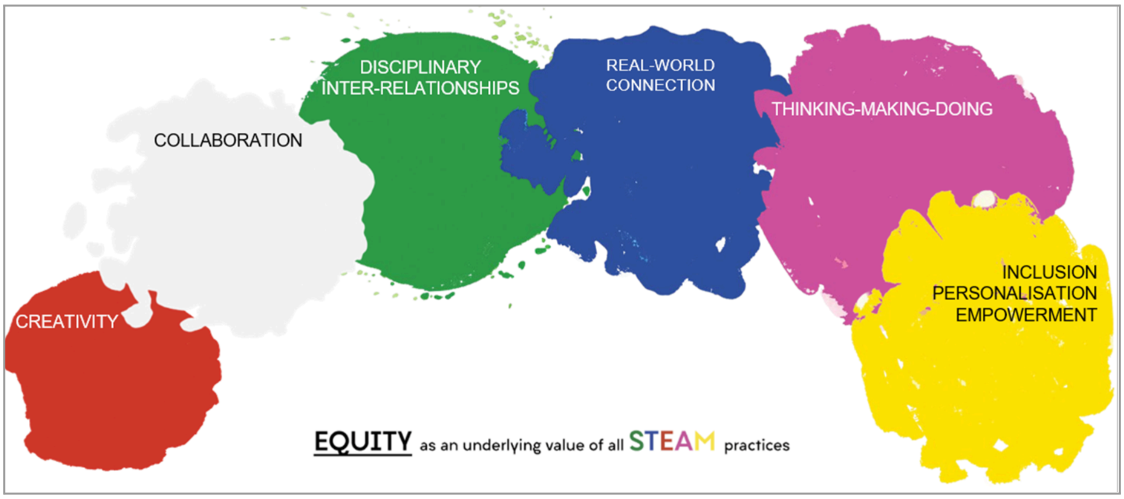

Figure 4: The Road-STEAMer project criteria (D4.1)

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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 5).

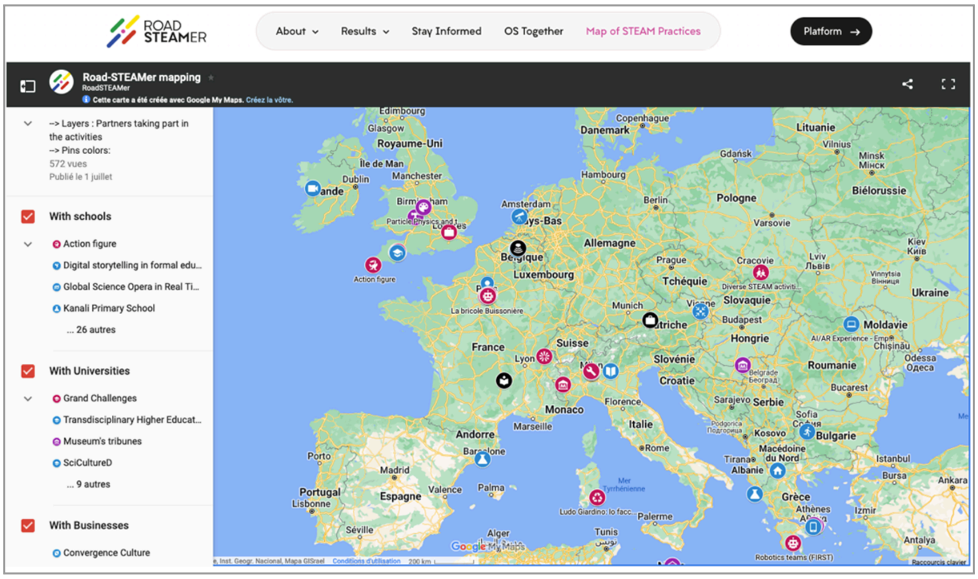

Figure 5: The Road-STEAMer interactive map of STEAM projects and practices

Secondly, the Road-STEAMer project demonstrates the relationship between the criteria (Fig. 4) and their manifestation within STEAM projects and practices (Fig. 5). 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 6 and 7. 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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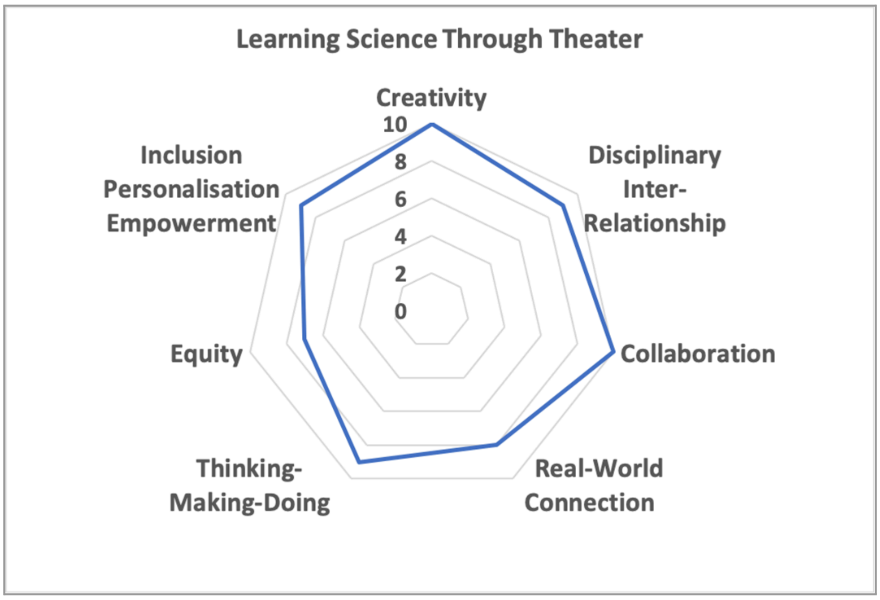

Figure 6: Radar diagram of Learning Science Through Theater evaluated according to the criteria

Figure 6 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.

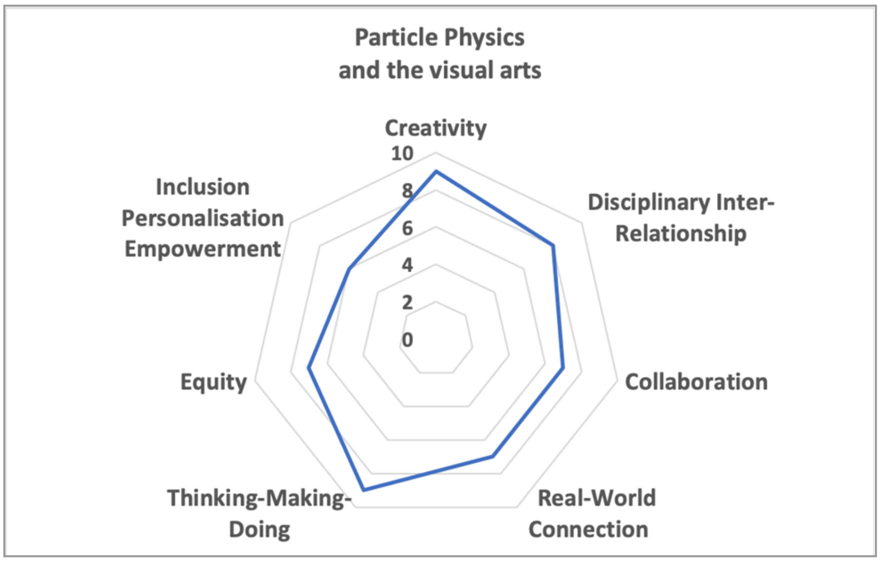

Figure 7: Radar diagram of Particle Physics and the visual arts evaluated according to the criteria

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Figure 7 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

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lead to sustained engagement and eventual career pursuits in related fields (cf. Gorard & See, 2009).

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).

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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; 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

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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 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 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 (Fig. 8).

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

- STEAM curriculum:
    - 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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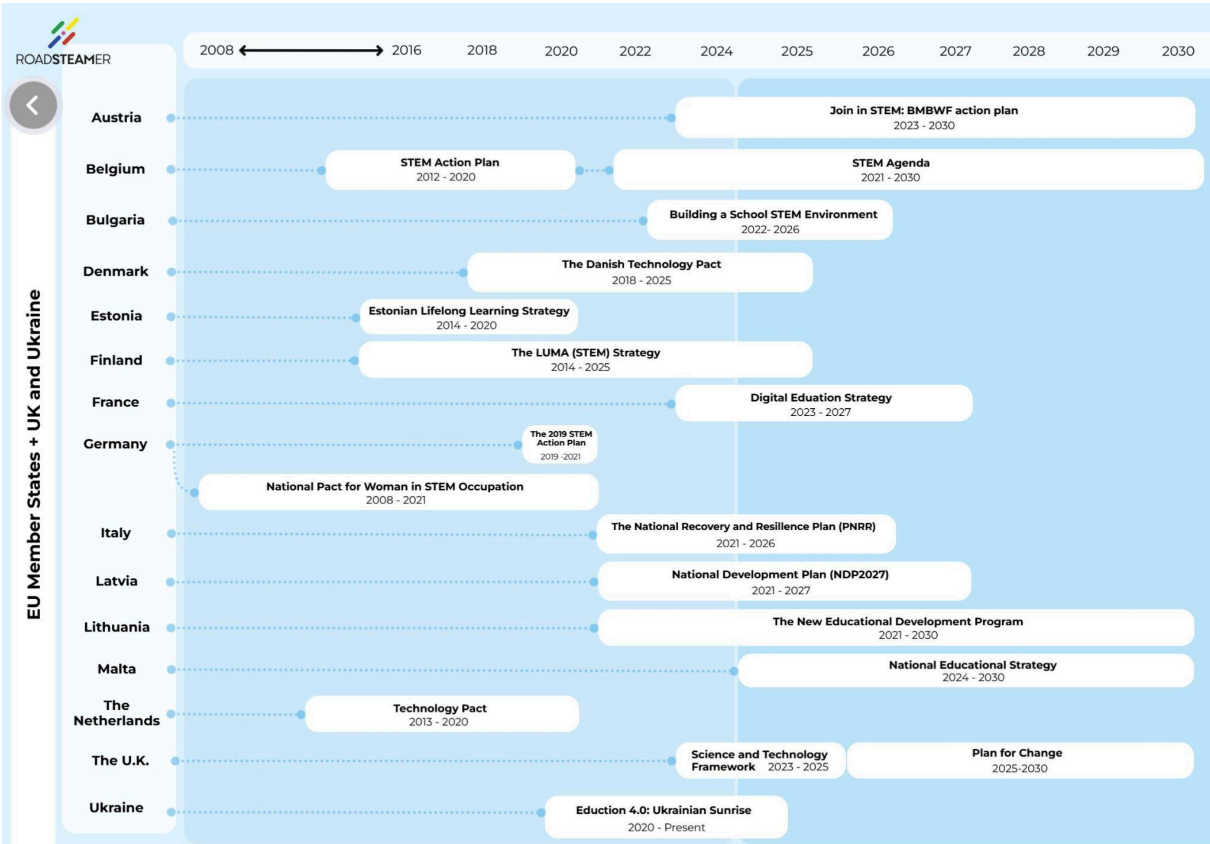

Figure 8: Timeline of STEAM plans in EU Member States.

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
   - Encourage Partnerships with Industry

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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 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

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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 recommended by the Road-STEAMer research. Arts and cultural literacy, crucial for social inclusion and cohesion, 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 on 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,

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including vocational education, as well as co-producing learning material that is project based, for mutual benefits.

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 fostering 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

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:

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- **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 recommendations 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 produce 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 aimed 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.
- **Girls self-ESTEAM** (2023-2025) Empowering girls through digital and entrepreneurial competencies to follow a career in ESTEAM
- **CREAM** (2021-2024) integrates creative writing with STEAM education through Creative Writing Labs (CWLs). Aimed at secondary school students, it uses storytelling to enhance engagement, creativity, and problem-solving in science-related

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subjects. Piloted across several European countries, the project produced toolkits, policy briefs, and videos to support wider adoption in classrooms.

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 (Fig. 9).

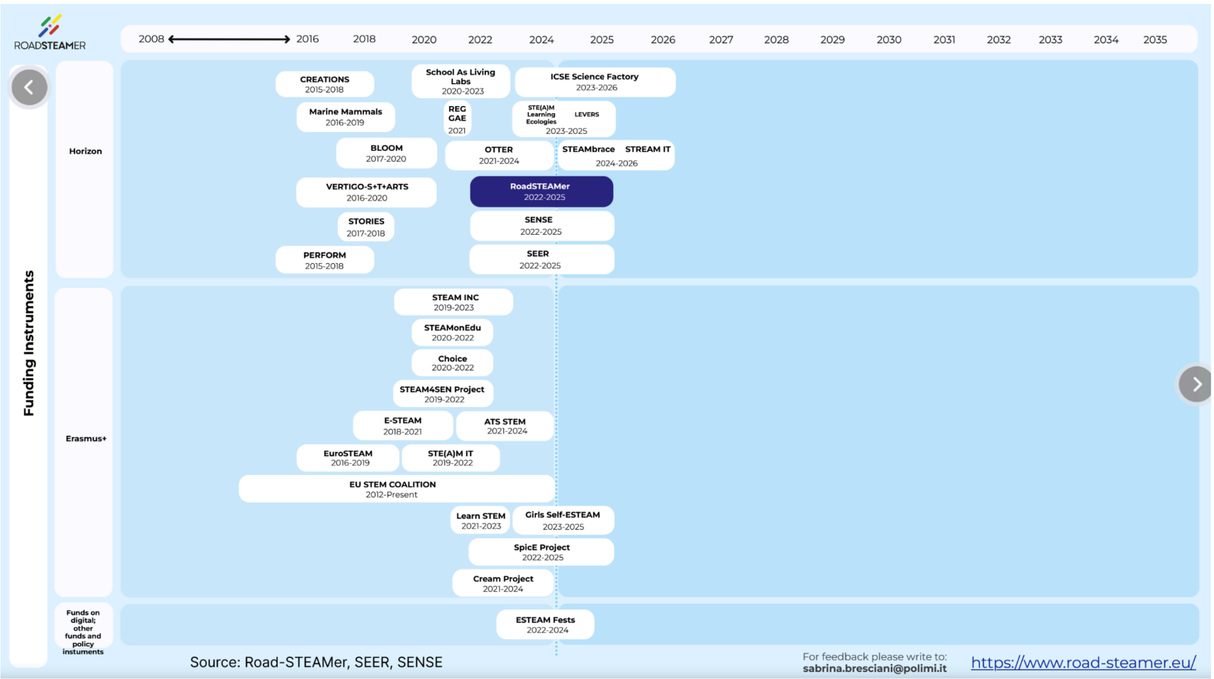

Figure 9: Previously EU funded calls and projects (interactive graph page 4)

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1.5. Co-design workshops with STEAM 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).

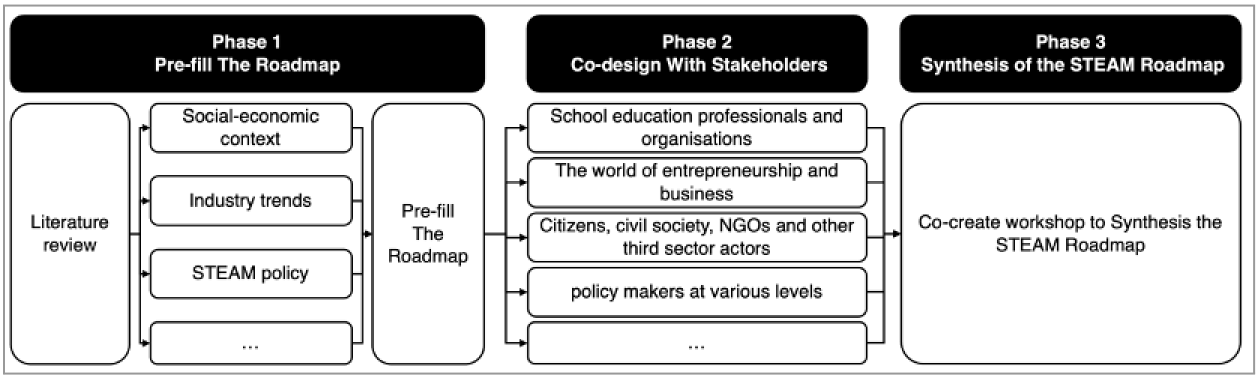

Figure 10: The policy roadmapping massive co-design methodology developed and deployed in this project

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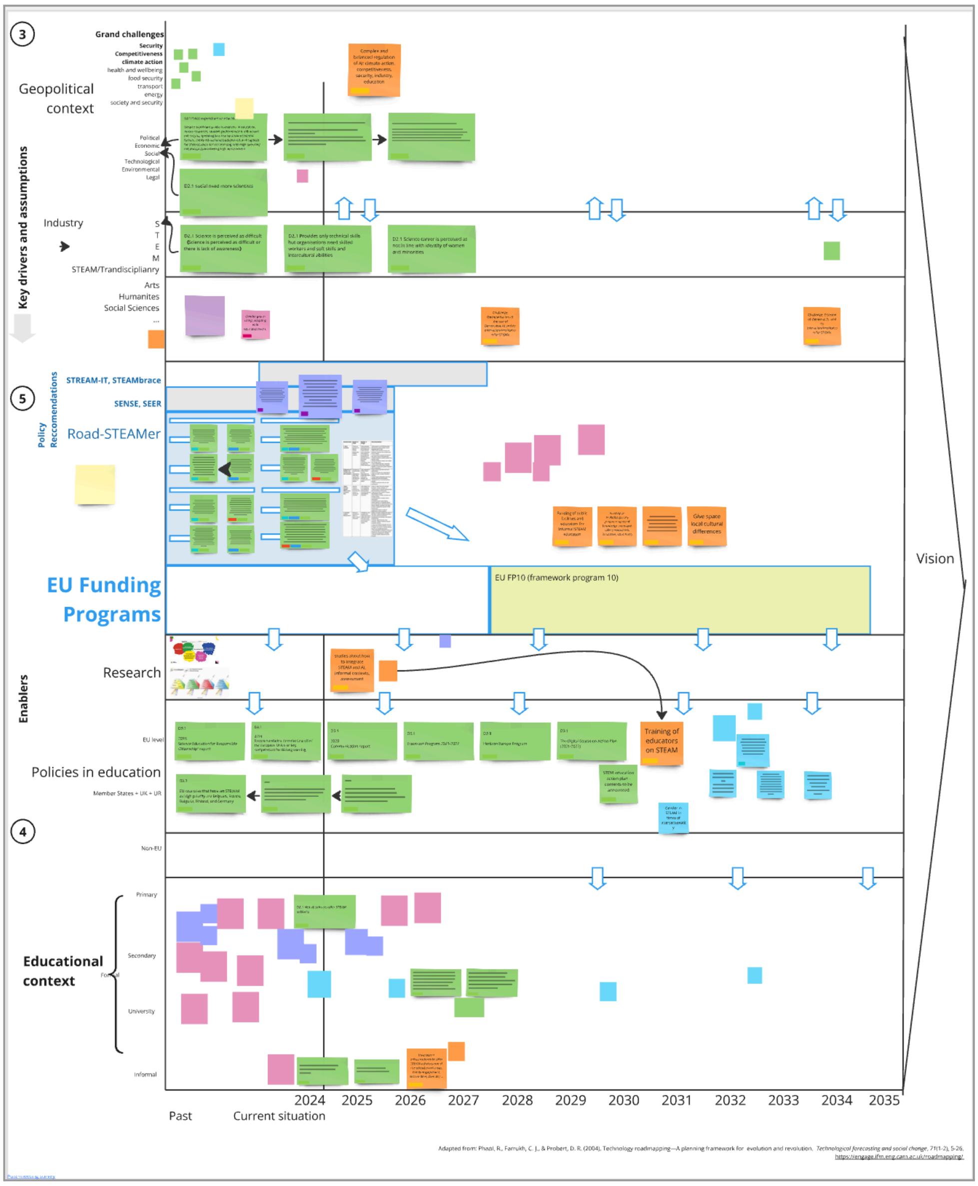

Figure 11: Illustrative example of one of the foresight co-design workshops outcome, facilitated with a pre-filled roadmapping canvas.

The methodology is structured into subsequent co-design steps, as illustrated in Figure 10. 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 11.

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

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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).

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.

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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 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

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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 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 of the interactive visual matrix and timeline

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; 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 12 and 13: 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 (provided in the pop-ups of the interactive version and in Section 2.2 of this deliverable), examples and references are provided, as well as the relationship with the STEM Education Strategic Plan 2025.

Compared to the first version of the roadmap published in D5.1, the final roadmap incorporates the feedback received in the testing phase (described in Chapter 3), with revised titles of the priority areas and of the specific actions, a clearer explanation of the systemic approach, additional examples, as well as an additional visualization of the same proposed actions according to a timeline, emphasizing time dependencies rather than funding programs, in response to the forthcoming changing foresee in FP10. As a result, the roadmap is presented in 2 formats with the same content:

1. Figure 12: an updated version of the matrix presented in D5.1 that outlines the actions for each priority area according to the potential funding and policy instruments, including in particular Horizon Europe and Erasmus+.
2. Figure 13: a timeline in which the same actions of the roadmap (Fig. 12) are mapped from the past to 2034 on the horizontal axis of the graph, and the priority areas are provided on the vertical axis. In addition, in the timeline version, the key milestones and actions of the Union of Skills and of the STEM Education strategic plan are mapped. The actions proposed in this deliverable are aligned from a time perspective, to the Union of Skills and STEM Education Strategic Plan.

The same content of the 30 proposed actions are provided in the next session, and have been progressively improved from April to July 2025 in response to the testing and feedback received.

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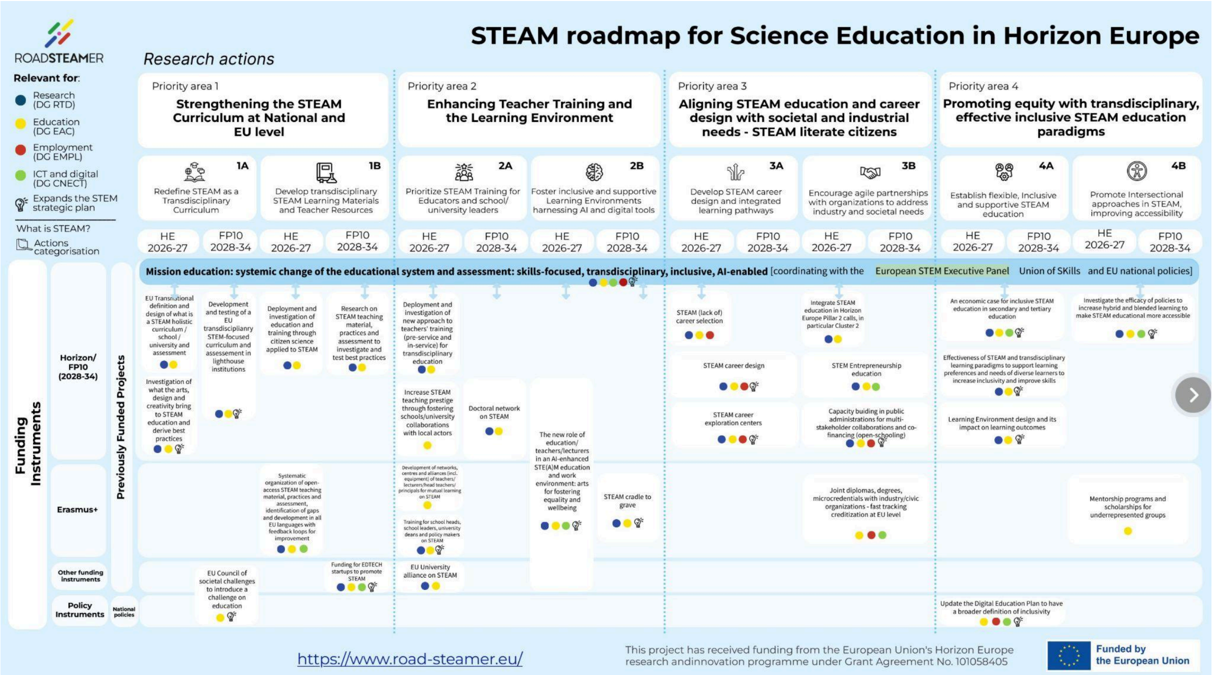

Figure 12: The visual [interactive roadmap](): matrix format

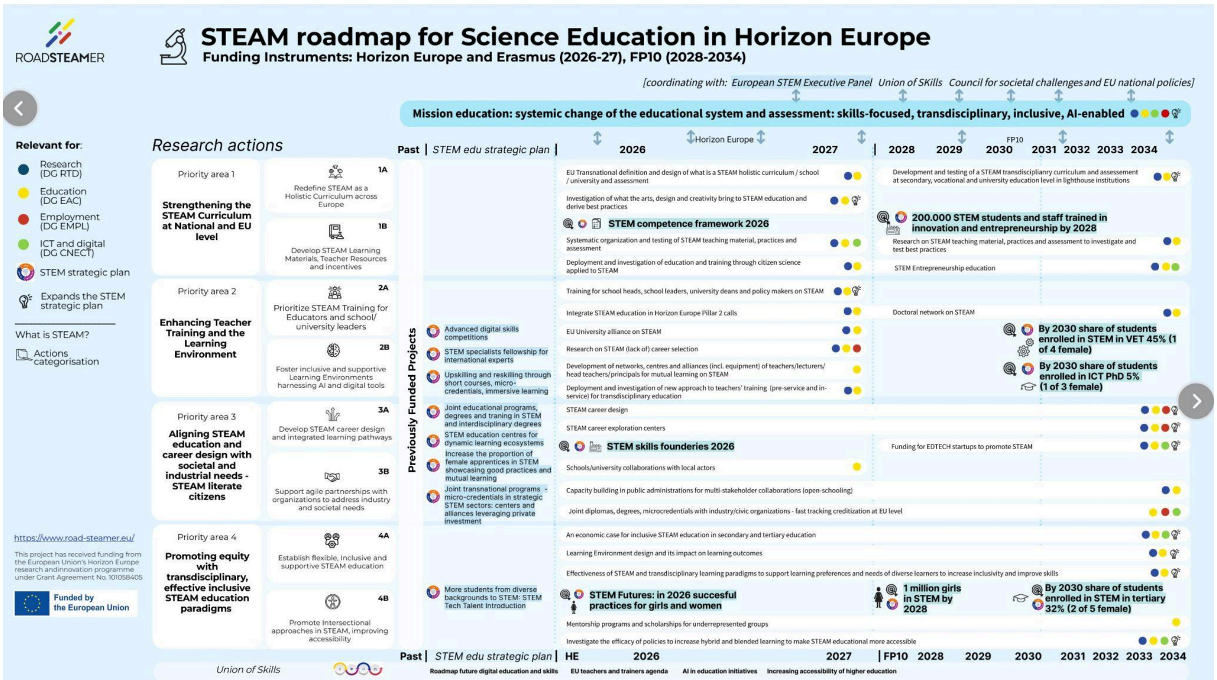

Figure 13: The visual [interactive roadmap](): timeline format

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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 transdisciplinary curriculum;

1b. develop transdisciplinary STEAM learning materials and teacher resources;

Priority area 2. Enhancing teacher training and the learning environment

2a. prioritize STEAM training for educators and schools/university leaders;

2b. foster inclusive and supportive learning environments harnessing AI and digital tools;

Priority area 3. Aligning STEAM education and career design with societal and industrial needs

3a. develop STEAM career design and integrated learning pathways;

3b. encouraging agile partnerships with organizations to address industrial and societal needs;

Priority area 4. Promoting equity with transdisciplinary, effective & inclusive STEAM education paradigms

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, such actions are mapped according to **key EU funding instruments**. Specifically, the core focus 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 and is envisioned to have a stronger role in education-related research in the next Framework Program..

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.

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:

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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.
- **Organizational meta-recommendations:** Efficiency of EU-funded projects and others.

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- **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. Aligning and Expanding with the Union of Skills and with the EU STEM Strategic Plan

According to the structure outlined, 30 specific coordinated research actions are proposed and 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 published by the European Commission on 5th March 2025. Such sub-section is written in order to connect to and offer developments to the EC STEM education strategy, indicating if each of the proposed actions supports or expands the plan (by providing novel input not foreseen in the STEM Education strategic document.

While the STEM Education Strategic Plan makes one explicit reference to STEAM (with “A”), the core focus of the strategic document is on a rather traditional view of STEM and STEAM and a focus on inclusivity that is exclusively related to the gender gap. 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. The relevance of both STEM and STEAM is already recognized by the EU and outlined in the EU policy brief “STEM and STEAM education, and disciplinary integration: a guide to informed policy action” published on 5th June, 2025 (Mazzeo Ortolani, 2025).

To better illustrate how the proposed research actions align with or expand upon the European Commission’s plans, the key actions, milestones, and anticipated strategic documents from the Union of Skills and the EU STEM Education Strategic Plan are mapped over time (Fig. 14). At the bottom of the image, the anticipated strategic documents of the Union of Skills are displayed. In the central area of the timeline, key milestones from the STEM Education Strategic Plan are marked with target symbols, aligned with their corresponding years as stated in the original document. Finally, the actions outlined in the STEM Education Strategic Plan are shown in a dedicated column and are vertically aligned with the priority areas proposed in this project (as described in the previous section).

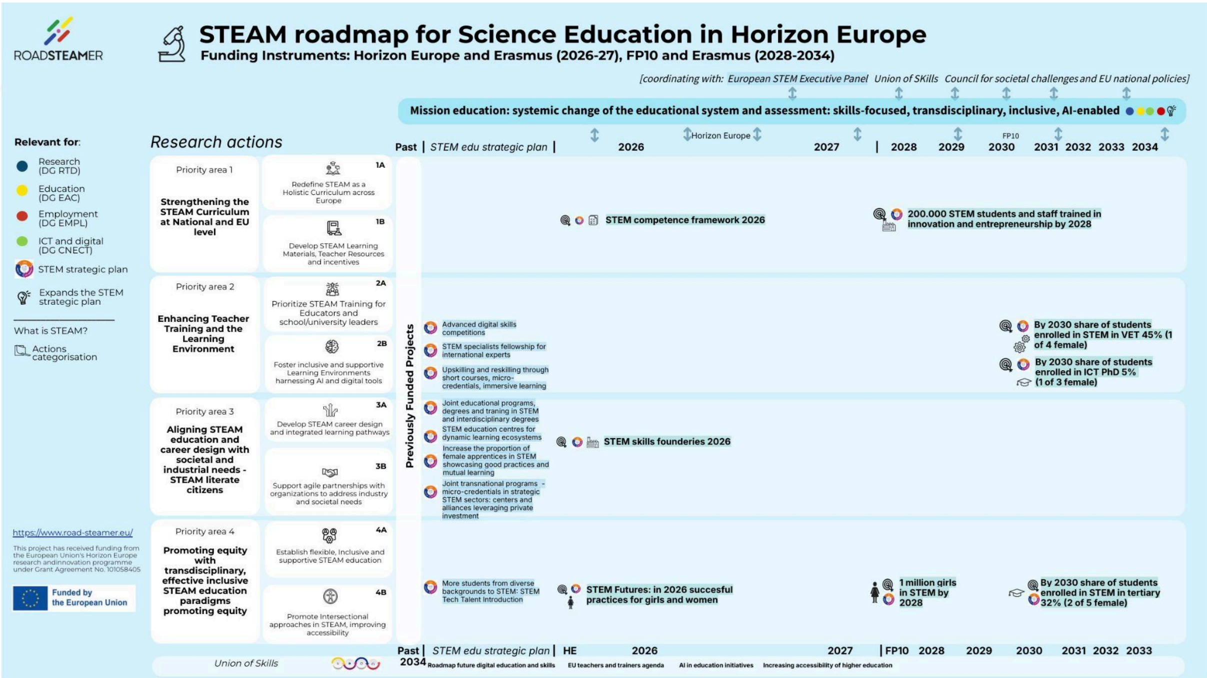

Figure 14: Mapping of the Union of Skills and EU STEM Strategic Plan key actions, milestones and strategic documents 2025-2030.

The 30 actions proposed in this deliverable are then added to the timeline to show the alignment and time dependencies, to the Union of Skills and STEM Education Strategic Plan (Fig. 13 in Section 2.1).

2.3. Proposal for a "Mission Education"

While numerous STEM and STEAM projects have been implemented over the years, as outlined above, and a substantial body of resources has been developed, these pilot initiatives and distributed resources still face significant challenges in scaling to achieve the widespread impact needed to meet EU objectives. Systemic barriers within national education systems—such as student assessment frameworks, limited teacher capacity, and structural constraints—continue to hinder the effective and inclusive scaling of STEM and STEAM education toward a truly skills-based, transdisciplinary approach.

The core recommendation of the Road-STEAMer project is to establish a long-term research initiative aimed at driving systemic change in the education sector. This would take the form of a Research "Mission," modeled on the structure of the current EU Missions under Horizon Europe Pillar 2 (e.g., Missions on Cities, Climate Adaptation, Soil, Oceans, and Cancer), as conceptualized by Mazzucato (2011, 2018, 2021). Such a mission would coordinate all EC-funded research actions in STEM, STEAM, and education, maintaining close collaboration with the forthcoming European STEM Executive Panels, the Union of Skills, and the Ministries of Education of EU Member States.

🔵***Systemic Action***: "Mission Education" - Systemic change of the educational system and assessment by orchestrating STEM/STEAM education research actions of EU funded projects for enhancing EU competitiveness through monitoring and scaling of actions for skills development, harnessing AI and digital technologies through a transdisciplinary inclusive approach to learning".

Description: Develop a Mission for the systemic innovation of EU education with the aim to orchestrate long-term systemic innovation for transdisciplinary inclusive technical education in the EU, though testing an EU curriculum and standardized testing, 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) and European Skills Intelligence Observatory, to support the development of 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 program could overcome the "fragmentation of resources across programs" (pg. 12). It would coordinate EU funded research projects, collecting and analysing qualitative and quantitative longitudinal data at every level (student, teacher, school, region, countries) to complement PISA assessment with more granular data, for the deployment and testing of digital education and AI in all educational levels, to scale existing successful projects and boost the opportunities that it provides for flexible (hybrid, blended, online) and inclusive (customized) skills-based STEAM education opportunities for vulnerable groups and learners with diverse abilities. It can be structured 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 European countries (as the National platforms in the Mission "Cities" and the "deep dives" of the Mission "Adaptation") to deploy and investigate a step-by-step progressive pathway toward project-based, transdisciplinary, AI-enhanced transdisciplinary

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(challenge-based or phenomenon-based) education in line with EU priorities. The Mission Education should coordinate the definition of mixed methods, process and outcome indicators and sensemaking processes, collecting data and monitoring step-by-step progressive pathways of STEM and STEAM practices (beyond disciplinary silos), programs, schools and universities in the EU - assessing beyond knowledge also life skills and mental health/wellbeing- to inform policy making for evidence-based educational reforms.

Potential funding instrument: *Missions in the* Horizon Europe Pillar 2, Missions in FP10 and/or Erasmus+ in FP10

Suggested time frame: 7-10 years from the present to the end of FP10 (2026-27 + FP10)

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).

STEM skills intelligence: Improve overall STEM skills intelligence based on international indicators and benchmarks, by measuring graduate outcomes in VET and tertiary education through the Eurograduate survey, and by 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.

Examples: EU Missions, Mission Cities, Mission Adaptation, Impact pathways in the Mission Cities

Evidence: Mazzuccato 2018, Mazzuccato 2021, Pokropek, 2025

Figure 15 provides an overview of the Horizon Europe pillars that are referred to in each action (section "potential funding instruments"). First introduced by the European Commission under the Horizon Europe program (since 2021), compared to general funded projects, Missions are large scale long term highly ambitious investments with clear time-bound goals that require systemic change to address global challenges. EU Missions are funded in Pillar 2 as can be seen in the figures (complemented by other EU instruments including the Cohesion Funds, LIFE, Digital Europe). For Horizon Europe, 5 Missions are funded (Fig. 16): Climate Neutral and Smart Cities, Adaptation to Climate Change, Restore our Ocean and Water, Soil Deal for Europe and Cancer.

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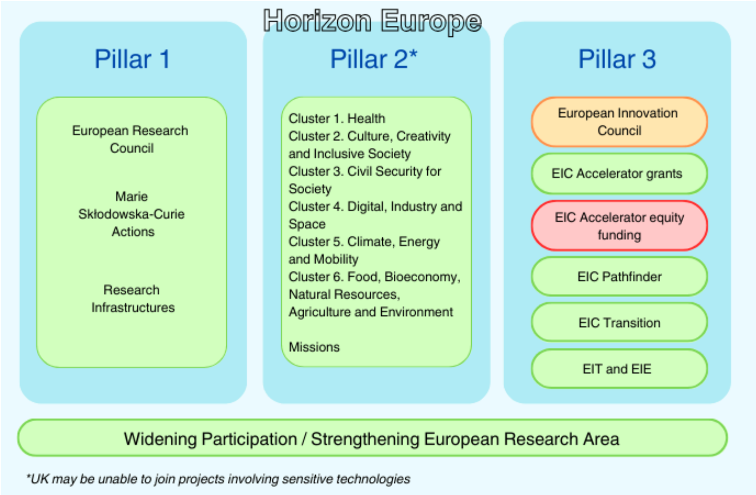

Figure 15: Structure of the Horizon Europe funding program

Figure 16: EU Research Missions

The concept of Mission oriented research and actions is proposed by the economist Mariana Mazzucato (Mazzucato, 2011; 2018; 2021), to reach specific objectives through systemic change through cross-sectoral collaboration and multi-level governance (including action at national and cross-national level). All five EU Missions have clear objectives to be reached by 2030 (from 2021):

- Mission Adaptation to Climate Change: Support 150+ regions and communities to become climate resilient
- Mission Climate-Neutral and Smart Cities: Support 100 cities to achieve climate neutrality
- Mission Soil Deal for Europe: Restore at least 75% of EU soils to healthy conditions

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- Mission Restore our Ocean and Waters: Protect and restore ocean and water ecosystems
- Mission Cancer: Improve the lives of 3+ million people through prevention, diagnosis, and treatment

All Missions are characterized by the design and implementation of a systemic approach through a coordinated portfolio of actions at the level of the Mission as well as at the level of the territory. Such a systemic approach requires experimentation and monitoring (with qualitative and quantitative methodologies) of actions in multiple domains of actions through several levers of change. Figure 17 provides three examples of the systemic approach of the Missions, including the creation of living labs (a concept similar to the open schooling approach on which RoadSTEMer is built upon), the [Regional Resilience Journey of the Mission Adaptation](), and the [impact pathways of the Mission Cities]().

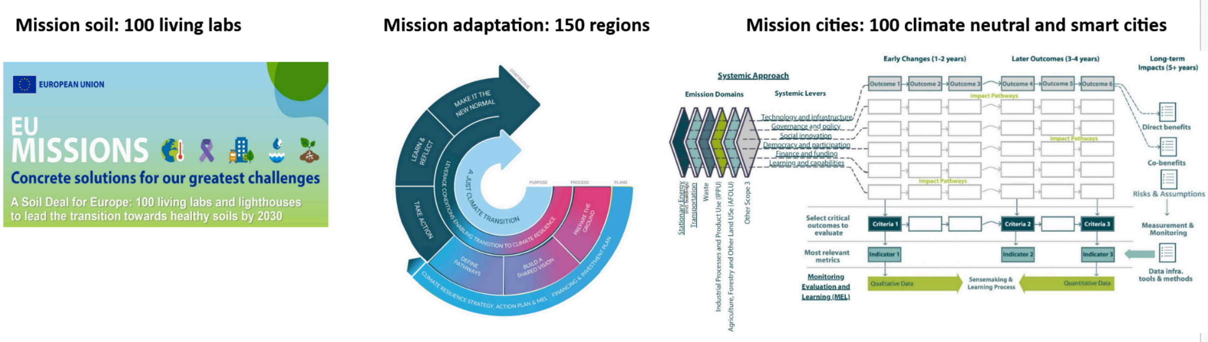

Figure 17: Systemic approach implemented in the EU Research Missions

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2.4. Specific recommendations for funding by priority area

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.

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)*

In response to the feedback received by stakeholders of the European Commission, examples of the actions are characterized with the categories defined in Figure 18, which facilitates identifying information as well as planning actions by educational level or magnitude of intervention.

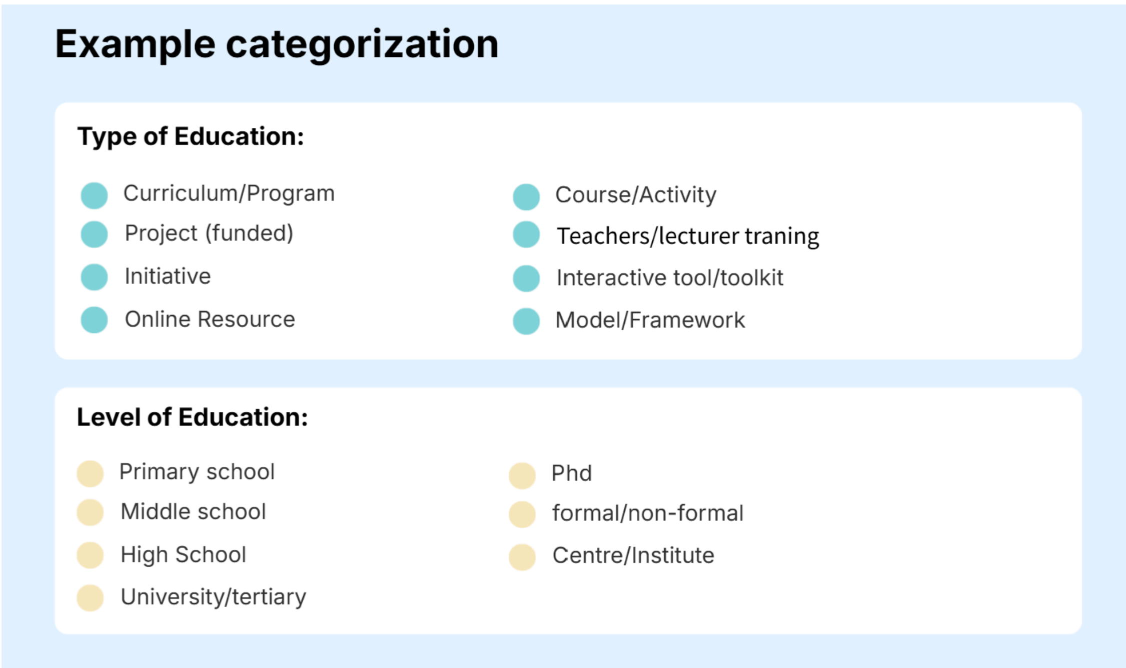

Figure 18: Categories for the examples of the actions

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

(1A) Redefine STEAM as a Transdisciplinary Curriculum in the EU

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

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.
- 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.

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- 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, Transdisciplinary education and innovation through STEAM

🔵🟡💡 ***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.

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Example of best practices:

- 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, Quantum Visions: It is a contemporary art exhibition curated by **Mónica Bello**, former Head of Arts at CERN, presented in 2025 as part of the International Year of Quantum Science and Technology. The exhibition explores how quantum physics concepts like uncertainty and entanglement inspire new forms of artistic expression and philosophical inquiry., Vertigo S+T+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), Defining STEAM Approaches for Higher Education 2021, Supporting Teachers to Foster Creativity and Critical Thinking: Cassie Hague OECD (CERI); STEM Competencies, Challenges, and Measurements (JRC, 2024); Colucci-Gray, et al. 2019

Funded by the European Union

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🔵🟡💡 *Action:* Development and testing of a EU transdisciplinary STEAM-focused curriculum in lighthouse institutions

Description: Development, deployment and testing of an EU transdisciplinary STEM-focused curriculum and assessment at secondary, vocational and university education level in lighthouse institutions 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 (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 Baccalaureate 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 Baccalaureate 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:India development of national curricula; International Baccalaureate transdisciplinary program, IB in public schools, STEAM Innovation in the Curriculum (STEAM INC), National College Resources Foundation (NCRF), Dulwich College (SE/21 Program)

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

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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 policymaking (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***

Evidences: Road-STEAMer D2.3, SENSE D4.4, SEER D3.2, Colucci-Gray et al. 2006, Banerjee & Duflo, 2009, 2011, JRC et al 2024;

🟡💡 ***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.

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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 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.

- CYBATHLON@school: An ETH Zurich program that teaches primary and secondary students about assistive technologies and inclusion through hands-on activities and simulations of disabilities. It promotes empathy, ethical reflection, and is aligned with the Swiss Curriculum 21, often involving ambassadors with disabilities to enrich learning.

More examples: Amsterdam University college - bachelor's program in Liberal arts and sciences

Potential funding instrument: EU council of societal challenges

Suggested time frame: FP10

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

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

Evidence: SENSE D4.3

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(1B) Develop and organize STEAM learning materials and Teacher Resources

🔵🟡🟢***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.

Example of best practices:

- Road-STEAMer 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.

- STIP COMPASS: STIP Compass is a joint platform by the OECD and European Commission that maps and compares Science, Technology, and Innovation (STI) policies across countries. It provides data on national policy initiatives, including their goals, funding, implementation tools, and responsible bodies. The platform supports evidence-based policymaking, promotes international collaboration, and helps users explore emerging trends and strategies in innovation policy.

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.

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,

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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), eTwinning
- ETH Zurich: The MINT Learning Center at ETH Zurich actively supports educators through comprehensive professional development programs aimed at enhancing STEM teaching skills. This includes training workshops where teachers learn to apply research-based, cognitively activating teaching methods that promote deep understanding and student engagement.
- Cream Project: An Erasmus+ initiative that integrates creative writing with STEAM education through Creative Writing Labs (CWLs). Aimed at secondary school students, it uses storytelling to enhance engagement, creativity, and problem-solving in science-related subjects. Piloted across several European countries, the project produced toolkits, policy briefs, and videos to support wider adoption in classrooms.
- Circular STEM

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

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🔵🟡🟢💡 ***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, 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, SchoolMint

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

Suggested time frame: FP10

Alignment with STEM Education Strategic Plan 2025: It expands the STEM strategic plan and alignes with EU priority of entrepreneurship.

🔵🟡***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).

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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 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)

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

(2A) Prioritize STEAM Training for Educators and school/university leaders

🔵🟡💡 ***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.
- 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 integration drafted 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.

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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 new approach to teachers' traning (pre-service and in-service) for transdisciplinary education (pre-service and in-service): STEM competence framework 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:

- 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*, LUMA Centre

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.")

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

Evidence: *SEER D2.2*, *Spyropoulou & Kameas, 2024*

🟡***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.
- 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.

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- *Other examples*: ArtsWork creating seven STEAM networks in SE England, STEAMalliance

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 collaboration between 11 leading research higher education institutions across Europe.
- EU STEM coalition is not focused specifically on universities but includes several typologies of European STEM and STEM actors.
- European Schoolnet: European Schoolnet is a network of 34 European education ministries that promotes innovation in teaching by supporting schools and teachers with digital resources, training, and collaborative projects to improve STEM and digital education across Europe.
- The European School Education Platform: It is the EU’s official online hub for school education, providing teachers and schools with tools for collaboration, professional development and Erasmus+ projects for primary and secondary education, and access to resources like eTwinning.

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More example: 4EU+

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 universities 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

Suggested time frame: 26-27 and FP10

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

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🟡 ***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 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

Funded by the European Union

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(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.
- 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), AI4T

Funded by the European Union

Road-STEAMer has received funding from the European Union's Horizon programme under grant agreement No. 101058405

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 I 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
- Horizon Europe call “Effective education and labour market transitions of young people”
- MINT Action Plan 2019 (in German): It Supports continuing education by promoting lifelong STEM learning, improving digital skills, and providing training and resources

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for educators. It ensures adults have access to quality MINT education to stay competitive in a tech-driven job market.

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) Aligning STEAM education and career design with societal and industrial needs - STEAM literate citizens

🔵🟡🔴***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

Funded by the European Union

Road-STEAMer has received funding from the European Union's Horizon programme under grant agreement No. 101058405

Suggested time frame: 2026-27

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 STEAM 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.

Evidence: Road-STEAMer D7.4

Funded by the European Union

Road-STEAMer has received funding from the European Union's Horizon programme under grant agreement No. 101058405

🔵🟡🔴💡 ***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 20 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 courses 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.

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- The University of Kaiserslautern: supports school students with STEM workshops, student ambassador talks, virtual labs, and an annual "Study and Career" lecture series, helping them explore study options and plan STEM careers.
- MINT 4 YOU – Girls Just Wanna Have Science: It is an annual event that encourages girls (grades 8–13) to explore STEM through hands-on workshops and activities. It connects participants with female scientists and professionals who share their experiences, providing inspiration and informal mentorship during the event towards STEM careers.

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, 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.

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(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, 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. UP4MINT, STEAMhouse

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

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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***: Capacity buiding in public administrations for multi-stakeholder collaborations and co-financing (open-schooling)

Description: multi-stakeholder collaborations through open-schooling fuse the STEAM approach, 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. SENSE, SEER). 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. Schools and universities innovate their role – aligned with Europe's vision of systemic change implemented in the EU Missions– which is enacted through a revised role of public institutions as enablers of systemic change by activating the local ecosystem, empowering trainers and learners to become themselves agents of change (SENSE). The investigation of the effectiveness of partnerships could 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 and societal challenges, 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

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(SEER). Collaboration with industries and living labs can provide the necessary labs and materials for STEAM activities.

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

🔵🟡***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

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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, including activities 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 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

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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 high school programs and university degrees focused on supporting learners to develop their own businesses.

Example of best practices:

- ***BUILD program:*** entrepreneurship programs from few hours to 3 years, embedded in the school program (USA)
- ***Switzerland Venture program****: the state-financed 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 Berkeley 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

Suggested time frame: 26-27

Related policy recommendations: Road-STEAMer recommendation 6

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Priority Area 4: Promoting equity with transdisciplinary, effective and inclusive STEAM education paradigms

(4A) Establish flexible, inclusive and supportive STEAM education

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

Description: The planned revision of the Digital Education Plan should ensure 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 levels 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: 2025

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

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Road-STEAMer has received funding from the European Union's Horizon programme under grant agreement No. 101058405

🔵🟡🟢💡 *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 Autism 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

Evidence: SEER D3.1, Perales & Aróstegui, 2024, OECD Learning Compass for Mathematics

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🔵🟡💡 ***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 Baccalaureate 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 in the 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
- Tandem.MINT: a **university-level language and cultural exchange program** at Ruhr-Universität Bochum (RUB), tailored for students in STEM fields (Mathematics, Informatics, Natural Sciences, and Technology). It pairs students with partners who are native speakers or proficient in the target language, facilitating mutual language practice and cultural exchange.

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

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🔵🟡💡 ***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 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 Erasmus+ 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+

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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,

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 policies to increase 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.

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- Revere High School (USA): successfully transformed 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 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

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🟡*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:

- *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 disadvantaged 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.
- Swiss TecLadies: A national mentoring program by the Swiss Academy of Engineering Sciences for girls aged 14 to 19. It offers hands-on STEM activities and pairs each girl with a professional female mentor for personal guidance and support. It combines, according to their interests, stimulating meetings, interactive workshops,

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exclusive visits to universities and cantonal schools, company visits and networking in the field of science and technology.

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 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

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3. Finalisation of the roadmap: testing, feasibility and impact

3.1. Testing and Feasibility of the Road-STEAMer Roadmap

The roadmap of research actions to increase the uptake of STEAM presented in Chapter 2 is a revised version of the first version of the roadmap presented in D5.1 “STEAM roadmap for science education in Horizon Europe v1” delivered on April 29th 2025. This chapter outlines the testing conducted, the feedback received and the changes made, that are already implemented in the roadmap actions presented in Chapter 2. In the following Section of this chapter (3.2), the impact of the suggested actions is presented.

This section describes evidence-informed assessment of the feasibility of the Road-STEAMer roadmap. It draws directly on the extensive stakeholder engagement activities (see Appendix A for more details and dedicated deliverables) conducted by the Road-STEAMer consortium following the release of the first beta version of the interactive roadmap in March 2025. The purpose of these activities was twofold: to test the relevance and practicability of the proposed actions, and to collect targeted feedback on their feasibility across Europe’s diverse educational systems and across different European Commission’s funding schemes.

In total, since the first release of a beta version of the interactive roadmap in March 2025, 14 feedback sessions/events have been held in diverse formats (2 of which were already reported in D5.1 and summarized below for completeness). 2 additional events, 5 workshops, 1 dialogue, 6 presentations to conferences and feedback through the Road-STEAMer online platform have been organized in between 30th April and 2nd July 2025 with a wide and diverse set of participants, allowing the consortium to gather perspectives from a broad range of education and innovation stakeholders.

After a first testing within the consortium partners, a workshop was organized in March 2025 to gather input, feedback and improve coordination with projects funded under the same call: SEER and SENSE.

Particularly valuable feedback was gathered during a digital workshop held on 2nd April involving policymakers from various departments of the European Commission. These included representatives from the Directorate-General for Education, Youth, Sport and Culture (DG EAC), the Directorate-General for Research and Innovation (DG RTD), the

Directorate-General for Communications Networks, Content and Technology (DG CNECT), the Directorate-General for Research Executive Agency (DG REA), and Unit C4 – Digital Education within DG EAC. Based on the feedback, references to related projects and deliverables were added to the roadmap (first version) as described in D5.1. While this workshop took place prior to the release of v1, some recommendations were incorporated in V1, while the format of the timeline was incorporated into v2 as it required more time for implementation.

A key moment in the consultation process was a dedicated session with European Commission policymakers, as well as the presentation of the roadmap's first version on 30th April 2025 at the high level "Expert Lunch on STEAM Education: The Road Ahead" organized at the Lisbon Council premises in Brussels (Residence Palace). This event included an official speech (closing remarks) by Francesca Maltauro, Deputy Head of Unit, Digital Education Directorate-General for Education, Youth, Sport and Culture, European Commission, and brought together leaders from policy, academia, and industry, including DG EAC (3 additional participants), EIT, EIT digital, Permanent Representation of Ireland to the European Union, European Schoolnet, Eurochambres, and three universities in addition to the project consortium (Fig. 19). The feedback gathered from DG EAC, EIT and other participants during this occasion has shaped the adaptations of the roadmap to improve feasibility and alignment with EU political and strategic priorities, as well as industry needs, and extra-EU development of STEM education.

Figure 19: Expert Lunch on STEAM Education: The Road Ahead

In the same location in the afternoon, the "2025 Skills Summit - Transforming STEM Education for Competitiveness and Social Fairness" took place. The Summit was opened by Roxana Mînzatu, Executive Vice-President of the European Commission for Social Rights and Skills, Quality Jobs and Preparedness (Fig. 20).

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Figure 20: "2025 Skills Summit – Transforming STEM Education for Competitiveness and Social Fairness" took place, opened by Roxana Mînzatu, Executive Vice-President of the European Commission for Social Rights and Skills, Quality Jobs and Preparedness

Based on the feedback received in these workshops with the European Commission representatives and stakeholders from industry and society, the roadmap actions have been revised to feature a categorization of the examples and actions, as well as creating a timeline version of the same content.

The revised version of the roadmap has then been tested in additional workshops, in particular:

- with School leaders, conducted by ESHA - the European School Heads Association,
- with academics, conducted by/at the University of Exeter,
- with bachelor and master students, conducted at/by Politecnico di Milano,
- with coordinators of both sister projects funded under the same Horizon Europe call (SENSE and SEER) and other related "cousin" projects funded by Horizon on STEAM (i.e. STREAM-IT and STEAMbrace) conducted in June for further testing specifically on feasibility and updated on the coordination between projects (compared to the previous workshop held in March),
- with special education experts and parents of children with autism spectrum disorder,
- with entrepreneurs (dialogue).

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Additional participatory input was collected through the Road-STEAMer Community of Practice Suite (CoP), based on the Decidim platform, utilized for supporting the testing workshops as well as being advertised on social media channels as open to any online participant wishing to provide feedback. The CoP recorded nearly 60 interactions, including comments and endorsements. These interactions helped validate the relevance of the proposed actions and surface user-generated insights on feasibility constraints and opportunities for further improving the roadmap. More information can be found in the Appendix F: Testing the roadmap through the participatory platform.

The RoadSTEMer roadmap and related analysis have been and will be presented in academic conferences, which also provided and will provide occasions for both receiving feedback through the peer review process and presentations, as well as disseminating Road-STEAMer work (see Reference list for more details):

- British Educational Research Association Conference 2024, Manchester UK, September 2024, 9 - 12 September 2024;
- SpicE International Conference on Inclusive STEAM Education. Patras, Greece, and online. 30-31 May, 2025;
- HEAd'25 11th International Conference on Higher Education Advances, Valencia, Spain, 17 – 20 June, 2025;
- Futures of Technologies – Mutual Shaping of Socio-Technical Transformations, 10-12 June 2025, Turku, Finland;
- EduLearn25: 17th annual International Conference on Education and New Learning Technologies, Palma, Spain, 30 June – 2 July, 2025;
- European Science Education Research Association Conference 2025, Copenhagen, Denmark 2025, 25-29 August 2025;
- British Educational Research Association Conference 2025, Brighton UK, 9 to 11 September 2025.

Finally, Road-STEAMer consortium members participated to the “Validation seminar - Study on promoting STEM education in Schools” organized by Technopolis group on 17th June : in this case there was no presentation of the Road-STEAMer work, which were only participants, but the content of the seminar was very relevant as a term of comparison to validate or improve the content of the Road-STEAMer roadmap proposed actions. The presentation of the seminar was analysed in detail to identify potential additional references to be incorporated in the roadmap (such as best practices from specific EU countries). The Road-STEAMer roadmap and deliverable had been shared with the seminar organizers for mutual learning.

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For a more extended description of workshops methodology and participants, see Appendix A. For a comprehensive overview of the Road-STEAMer participatory platform see Deliverable 1.4.

The main feedback and feasibility testing insights received in the above described testing sessions, are summarised in Table 1.

Table 1. Main feedback received regarding feasibility and general suggestions for improvement

Category	Feedback on relevance and feasibility
1. Strategic level	- Show dependencies between actions (what needs to be done first), organized by key priority areas - Indicate at which level the action needs to be implemented / levels of education relevant to each action's ownership, along with the type and dimension of listed initiative - Clarify key definitions (e.g., "arts" in STEAM) - For proposed action, include implementation details —specifying responsible actors, national vs. local level, identifying key challenges and opportunities, and outlining how the action can be replicated in other contexts. - Consider DG Connect, education to entrepreneurship - Is change going to be incremental? It is difficult to change the system because countries are proud of their national curricula - Include previously funded projects on STEM and STEAM to show building on what has already been financed - It's relevant that the actions are aligned with the STEM Education Strategic Plan and EU policies - In FP10, research on education might receive more funding in the Erasmus+ program - Explain what is a Mission - It's crucial to target school heads for STE(A)M training - Unanimity on the relevance of career centers / simulation / guidance - Relevance of investigating barriers for girls and vulnerable groups in STEM Education before implementing policies and changes
2. Inclusive and Pedagogical Approaches	- Emphasize Universal Design for Learning (UDL) as a key inclusion tool - Plan curriculum revision before initiating changes in teacher training and learning environments - Teacher training and pedagogical innovation is needed before implementing curriculum reform.

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	- Develop data-informed engagement strategies to address gender disparities. - Consider how students and people in general will learn with AI and VR: the educational sector needs to evolve or people will learn informally - Inclusive education does not mean to have all students with diverse needs in the same class but rather to offer a variety of options for a variety of learners' needs, including different and specific learning spaces
3. Governance and Sustainability	- Ensure institutional and financial alignment with EU policy instruments - Expand the scope to include early years and adapt to national educational systems - Acknowledge the difficulty of implementing long-term changes within short-term political cycles, as most policy changes extend beyond typical 4-year terms
4. Evidence and Accountability	- It's very important to build the economic case for inclusive STEAM through longitudinal research. - Establish effective monitoring tools to track progress and ensure accountability.
5. Financing and Partnerships	- Promote diverse financing mechanisms, including microfunding and cross-sector partnerships. - Need guidelines for legal aspects for schools to embed/collaborate/be financed by the private sector to make sure students are not exploited and at the same time industries find value in the collaboration

In addition to the key feedback described in the table, participants provided input on specific examples, which are directly added to the roadmap (Section 2.1) and briefly outlined in the next section, which describes modifications implemented to the second version of the roadmap in response to this consultation process.

Improvements implemented based on the feedback received

To improve the feasibility, precision and comprehensiveness of the overall roadmap and of the 30 actions proposed, all feedback received was considered and implemented in the updated version of the roadmap presented in Chapter 2.

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To provide readers with an overview of the key changes implemented based on the feedback received in the testing phase of the project, the main changes are outlined:

1. **Visual format: timeline and mapping of Union of Skills**

   An additional visual format with the same content is created in the form of a timeline, in response to the suggestions by the EC workshop participants, to clarify which actions should come first (Fig. 13)

   This additional format was enriched with the mapping of the objectives and actions of the Union of Skills and STEM Education Strategic Plan (Fig. 14).

2. **What is a Mission and systemic change**

   While the key target audience of the roadmap is the European Commission, the Road-STEAMer project aims to release a final version of the roadmap that is understandable by all STEAM community stakeholders. Feedback was received from stakeholders that the concept of the “Mission” was not self-explanary, therefore the description of the main action “Mission Education” - Systemic change of the educational system and assessment by orchestrating STEM/STEAM education research actions of EU funded projects for enhancing EU competitiveness through monitoring and scaling of actions for skills development, harnessing AI and digital technologies through a transdisciplinary inclusive approach to learning” is enriched with a more extended description, as outlined in Section 2.2.

   A related question was received by stakeholders including members of the European Commission on the feasibility of the radical systemic transformation proposed, compared to a more incremental change. The Road-STEAMer project proposes a systemic transformation of the education field rather than incremental steps, precisely as the EU Mission are doing in other sectors, to disrupt locked-in systems, given the unprecedented changes in digital technologies, mental health emergencies especially among the youngests, and current geo-political and economic challenging situation.

   The Road-STEAMer project proposes a systemic innovation of the educational field to become skills-focused, transdisciplinary inclusive, enabled by digital technologies and AI. While shifting from a traditional teaching approach with students sitting in class listening to lectures by subject, to an educational system that has a focus on technical

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and smart skills (Padurean at al. 2022), has a related a skills-based assessment, is by default transdisciplinary (Colucci-Gray, et al. 2019), opening up to societal and industry relevant collaborations with local actors (civic organizations, industries, SMEs, local experts and facilities), might seem an immense challenge, such type of education already exist.

The International Baccalaureate (IB) program might be the most popular of such skills-focused interdisciplinary curricula (especially for the Primary Years Program), currently attended by about 2 Millions students in 162 countries from kindergarten to high school. The International Baccalaureate Organization is a non profit foundation established in 1968 in Switzerland. While most IB schools are private, countries including Greece, Spain, Finland, Canada, Ecuador, Japan, Malaysia, South Korea, and USA have free IB programs in public schools, demonstrating that such transdisciplinary skills-focus existing programs can be replicated and embedded along with national curricula by National governments. The case of H-Farm is a particularly relevant example of STEAM hub: it is an IB school and college with a strong focus on STEAM, born out of a startup incubator. This unique setting, allows the school and college to foster entrepreneurship, open schooling and is by default a living lab. This model has recently been replicated in other 2 locations. It incorporates all the criteria and suggestions provided by the Road-STEAMer roadmap for education.

The non profit Still I rise - nominated for the Nobel Peace Prize in 2023- establishes and funds educational activities and IB schools in the for refugee children, as well as in the poorest countries or neighbourhoods (i.e., Naples in Italy) through fundraising activities, providing further evidence of the open schooling approach related to the IB program although not specifically focused on STEAM.

Finally, beyond IB programs, other education programs are being experimented. The International Experiential School (IEXS) is a notable example, listed among the top 10 schools worldwide, of a non profit skills-focused school that is conceived in the open school philosophy as a hub, however not specifically focused on STEAM and yet an example of educational system that is not only a systemic innovation but also “based on ecological webs and equity principles” (Coluccy-Gray, 2006), making the school the center of a self-sustaining ecosystem.

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Action

Development and testing of a STEAM transdisciplinary curriculum at secondary, vocational and university education level in lighthouse institutions

Co-design 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) for step-by-step progressive pathways, taking into account the STEAM criteria (Collaboration, Disciplinary inter-relationships, Thinking-making-doing, Creativity, Real-world connection, Inclusion / Personalisation / Empowerment and equity) and EU priorities (focus on skills-based education, digital skills, industry relations, etc.). To inform policies on intersectionality, studies should investigate the effectiveness of STEAM programs and holistic curriculum by variables of vulnerability (gender, country, disability, special learning needs, family background, family support, etc.), and teachers/lecturer ability of diverse curricula and teaching approaches, including a holistic curriculum based on challenges (such as climate change and health instead of subjects)

Examples

Roadsteamer STEAM criteria

H-Farm Curriculum · Primary School · Middle · High School

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 Curriculum · Middle

The holistic International Bacchlaurate curriculum Middle Years Programme (MYP) is enhanced with arts curriculum to encourages 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.

More examples: International Bacchalaureate transdisciplinary program · IB in Public Schools · IB in Greece · Still I rise · STEAM INC

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 (2028-34)

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

Evidence: Road-STEAMer D2.3 · SENSE D4.4 · SEER D3.2 · JRC et al 2024 · Banerjee & Duflo, 2009 · Road-STEAMer-D4.1 · Road-STEAMer-D2.2 · Durall, Carter & Burns 2022

Figure 21: Research on the implementation of a transdisciplinary curriculum

3. Financing

A key challenge in the implementation of STEM and STEAM education is the financing of labs, materials and activities, which are more expensive compared to traditional frontal teaching in class. This issue had already emerged in the developing phase of the roadmap, and led to the creation of an action related to multi-stakeholder collaboration, which is based on the open schooling approach, and is relevant specifically for the co-financing of materials, labs and STEAM initiatives.

From the testing sessions it emerged that co-financing through multi-stakeholder collaboration is an existing and emergent practices, which is however not free of challenges, in particular for two aspects:

1. The ability of schools/universities/public administrations *to mobilize the local ecosystem* to identify stakeholders for long term collaborations from sponsoring equipment, to providing facilities or spaces (i.e. companies' space and equipment), and from co-funding living labs or initiatives to co-teaching or students' development of projects proposed by organizations.

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2. The ability of schools/universities/public administrations *to handle procedures for external financing, sharing spaces or facilities, sponsoring or co-financing* of labs, materials, instruments and activities, and all the related accounting, ethical and regulatory challenges, especially when minors are involved.

These considerations have led to the renaming of the action into: "Capacity building in public administration for multi-stakeholder collaborations and co-financing (open schooling)" (Fig. 22).

With reference to the Mission approach described above, the systemic approach proposed is precisely focused on innovative financing as a leverage for systemic change, as currently under development in the EU Missions with experimentations in Living Labs (Mission Soil), Capital Hub and (EC-led) marketplaces (Mission Cities and Adaptation). Such experience from the EU Missions can inform the creation of the Education Mission with a strong foundation on innovative finance, which requires capacity building and guidance for public administrators and schools/universities training of public administrators in public finance, ethics and procurement.

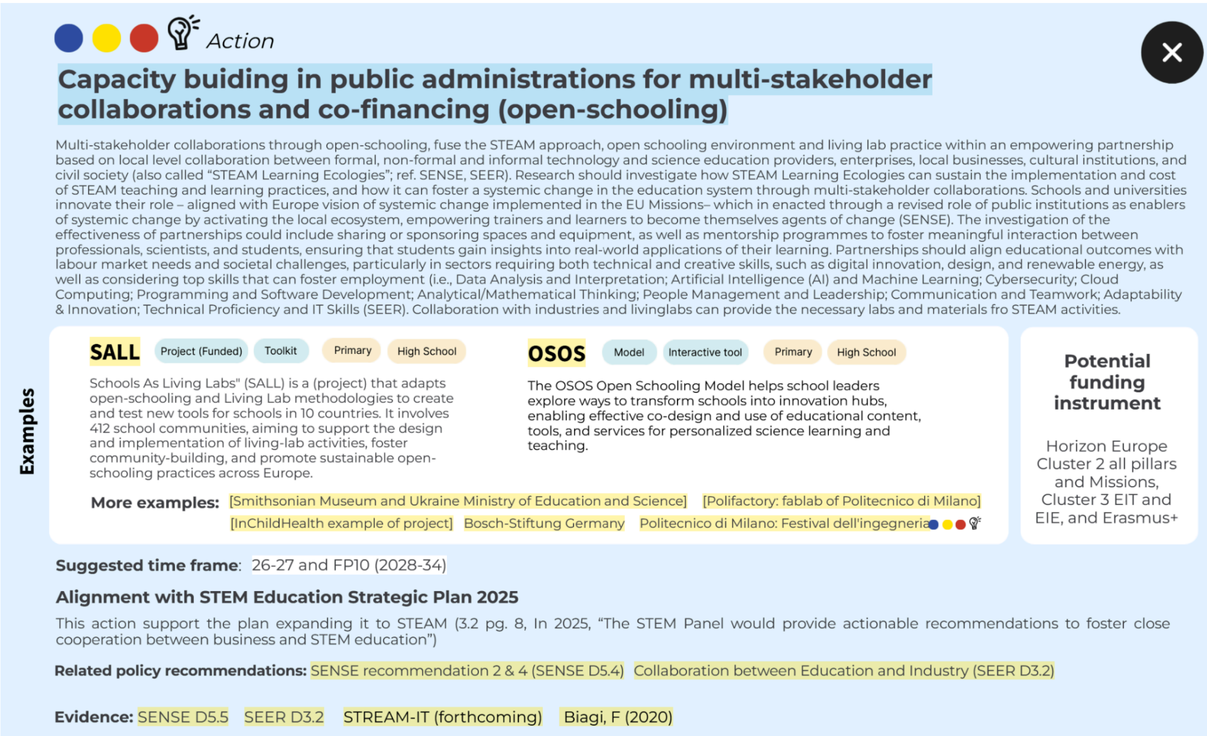

Figure 22: Revised action "Capacity building in public administration for multi-stakeholder collaborations and co-financing (open schooling)"

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4. Related DGs and EC priorities: Entrepreneurship and DG Connect

To implement feedback received from the European Commission's participants in testing workshops, the legend of actions's relevance was expanded to add the category of DG Connect which is particularly relevant given the relevance of digital education and the growing importance of AI shaping both education delivery and industry needs in terms of students' skills (Fig. 23).

Similarly, feedback was received regarding the relevance of education to entrepreneurship, thus a specific action was added "STEAM Entrepreneurship Education" (Fig. 24)

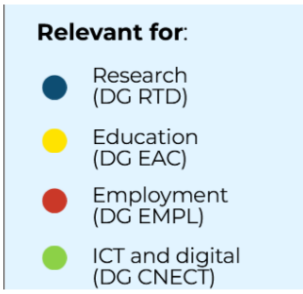

Figure 23: Screenshot of the roadmap legend

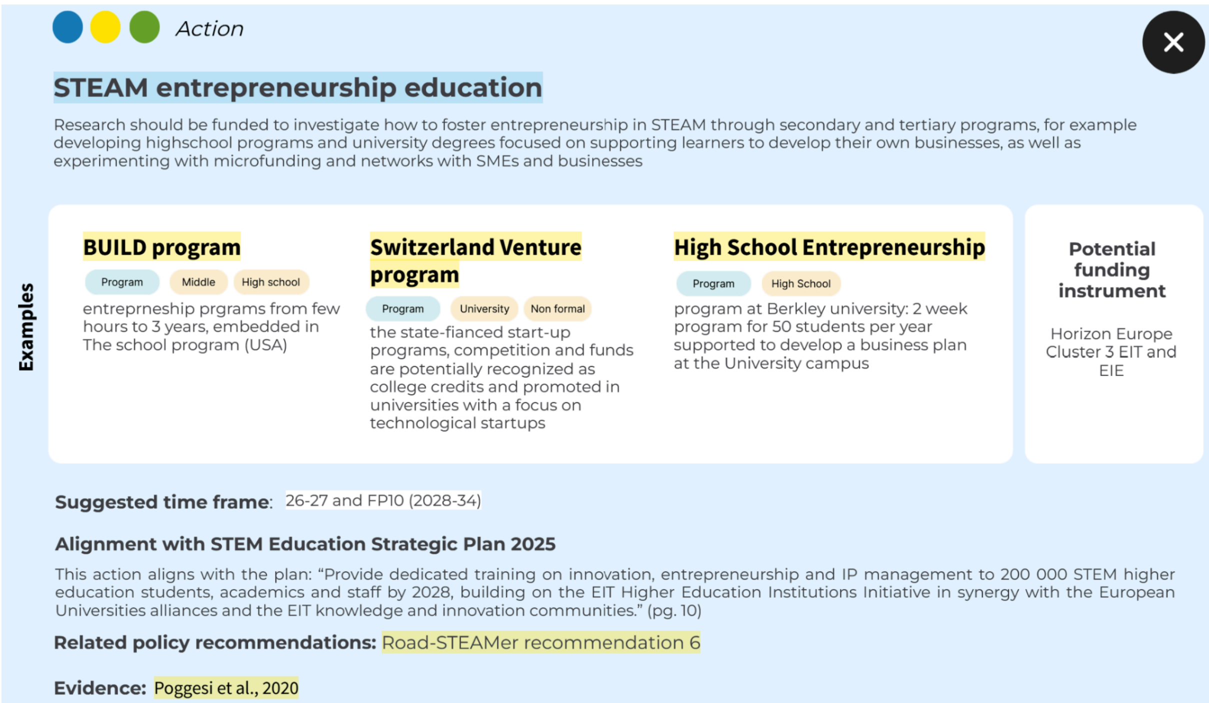

Figure 24: New action "STEAM entrepreneurship education"

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5. Categories

Each of the 30 actions contains examples and references. In the updated version of the roadmap, such actions suggestions and examples are categorised according to the education level (primary school, middle school, high school, university/tertiary, informal/non formal education such as museums, or others such as centres or institutes.

Secondly, each action or example, is classified according to the magnitude of the intervention: curriculum/program, (funded) project, initiative, course or activity, teachers training, toolkit, model/framework or online resource (Fig. 18).

6. Additional page with definitions

As all testing, especially in non-English speaking countries, reported that the acronym STEAM is not well known, or misunderstood, a page in the interactive roadmap was added (Fig. 25) with a definition of STEAM in the project Road-STEAMer, as well as the theoretical bases of the project which include the criteria and conceptual framework.

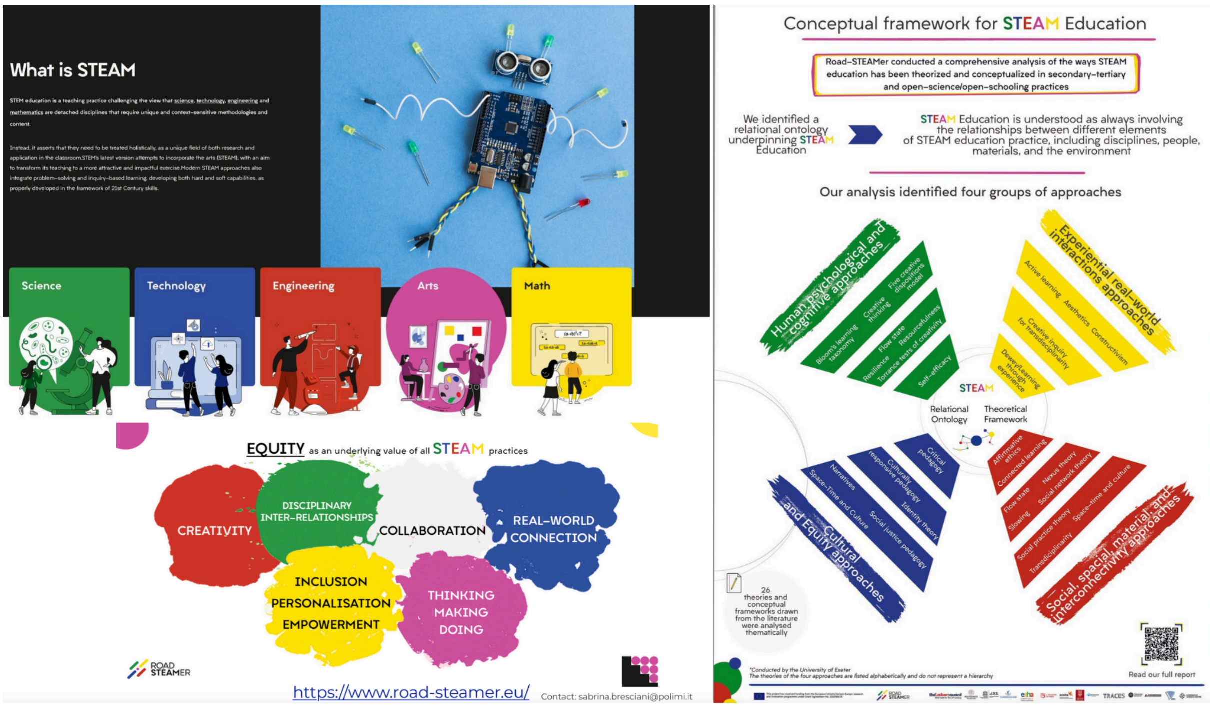

Figure 25: Additional page in the interactive roadmap with the Road-STEAMer definition of STEAM, the criteria and conceptual framework

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7. Additional projects and references

Based on the feedback and input received in the testing phase, several additional projects and references have been added to the actions. In particular the workshop with STEAM related projects provided additional reference regarding Universal Design, Design for All, as well as examples from the projects including the lab Odyssea developed by SENSE, which is reported in the action "Learning Environment Design and its impact on learning outcomes" (Fig. 26).

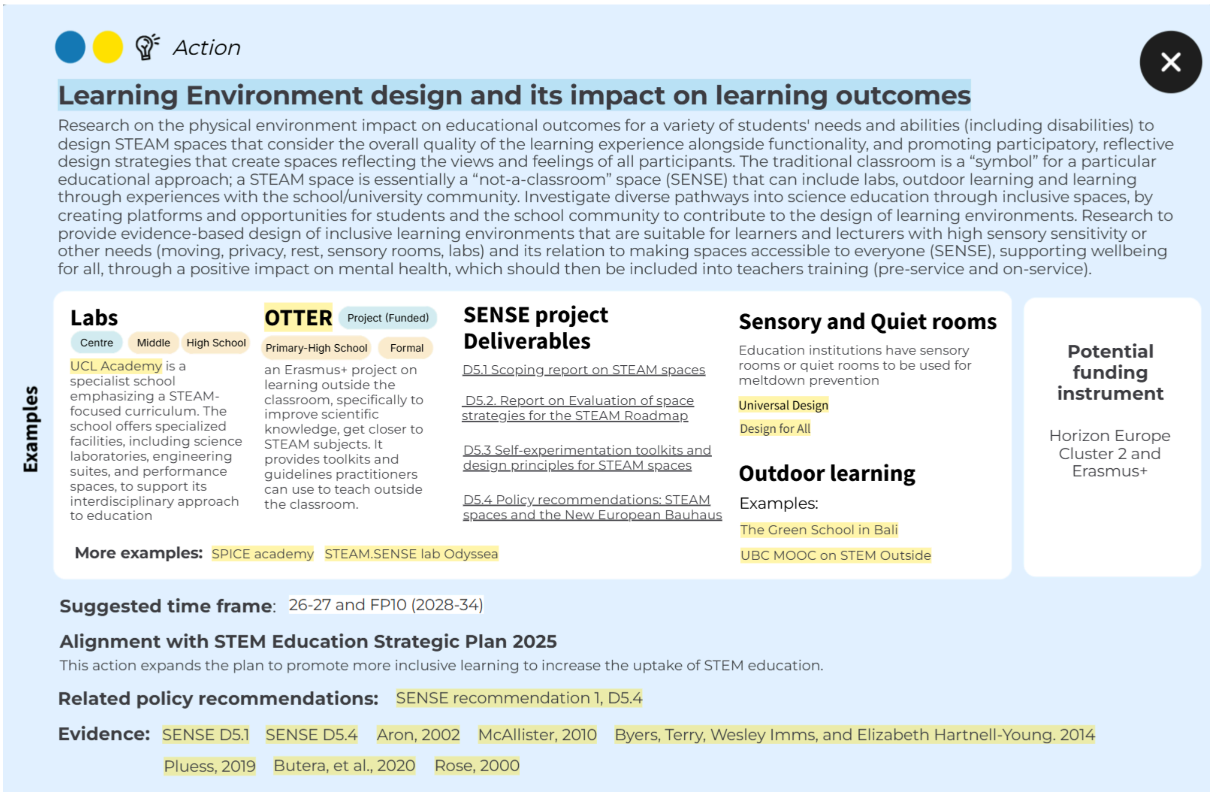

Figure 26: Additional examples and references for the action "Learning environment design and its impact on learning outcomes"

Thanks to input provided at the "Expert Lunch on STEAM Education: The Road Ahead", the action on joint diplomas and degrees has been expanded to consider not only the creation but "fast tracking" the recognition of new (joint) education programs, based on the example of non-EU countries policies to fast track university colleagues in weeks, compared to the year(s) long process typical in Europe (Fig. 27).

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Figure 27: Renaming of the action and restructuring of the examples by category and additional examples, including non-EU relevant policies regarding new and joint diplomas, degrees and microcredentials with fast track recognition

Among others the following examples have been added in the actions: Quantum Visions, Vertigo S+T+Arts, STEAM Innovation in the Curriculum (STEAM INC), National College Resources Foundation (NCRF), Dulwich College (SE/21 Program), CYBATHLON@school, STIP COMPASS, eTwinning, ETH Zurich, SchoolMint, STEAMalliance, The European School Education Platform, 4EU+, AI4T, European Schoolnet, MINT 4 YOU – Girls Just Wanna Have Science, UP4MINT, Tandem.MINT, Swiss TecLadies. Additional references have been included compared to the first version of the roadmap.

3.2. Impact and alignment to existing policies

The roadmap proposes actions to promote research on science and technology education mainstreaming in funded projects in Horizon Europe and various EU policy domains while aligning to industry and societal expectations and needs. The proposed actions, and in particular the overall "Mission Education" long-term research action, can provide the radical change required in the field of education to reach EU targets of competitiveness, social inclusion and digital literacy, compared to existing incremental actions and promotional "tactics" which do not change the underlying structure of an education system that was

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developed in a non-digital context. The recommendations provided in the roadmap are aligned to existing EU and national policies, strategies and agendas as described in Section 2, in particular to the Union of Skills and related STEM Education Strategic Plan, as well as national policies described in Section 1.3. For each of the 30 proposed research actions, the relevant DG(s) of the European Commission is indicated with the respective color (blue for DG RTD, yellow for DG EAC, red for DG EMPL and green for DG Connect) to indicate synergies.

Impact on education

The 30 proposed actions for research on STEAM education described in Chapter 2 aim to a systemic change of the educational system in Europe, aligned with the **goals of the STEM Education Strategic Plan** (as described in each single action in Chapter 2), and **aligned also with the planned strategic documents of the Union of Skills. More specifically, the proposed research actions can contribute to inform the Union of Skills envisioned "2030 Roadmap on the future of digital education and skills [Q4 2025]", and the proposed research actions can provide ideas, examples and evidence, can contribute in particular to the plan (forecasted for 2027) on "Increasing accessibility of higher education [2027]".** Figure 28 provides a visualized schematic view of potential impact on the proposed actions on the STEM Education Strategic plan (mapped inside the timeline with the target symbol), on the Union of Skills's upcoming plans (at the bottom of the timeline), and on the additional outcomes and impact proposed in the project (listed in the right-hand side of the image).

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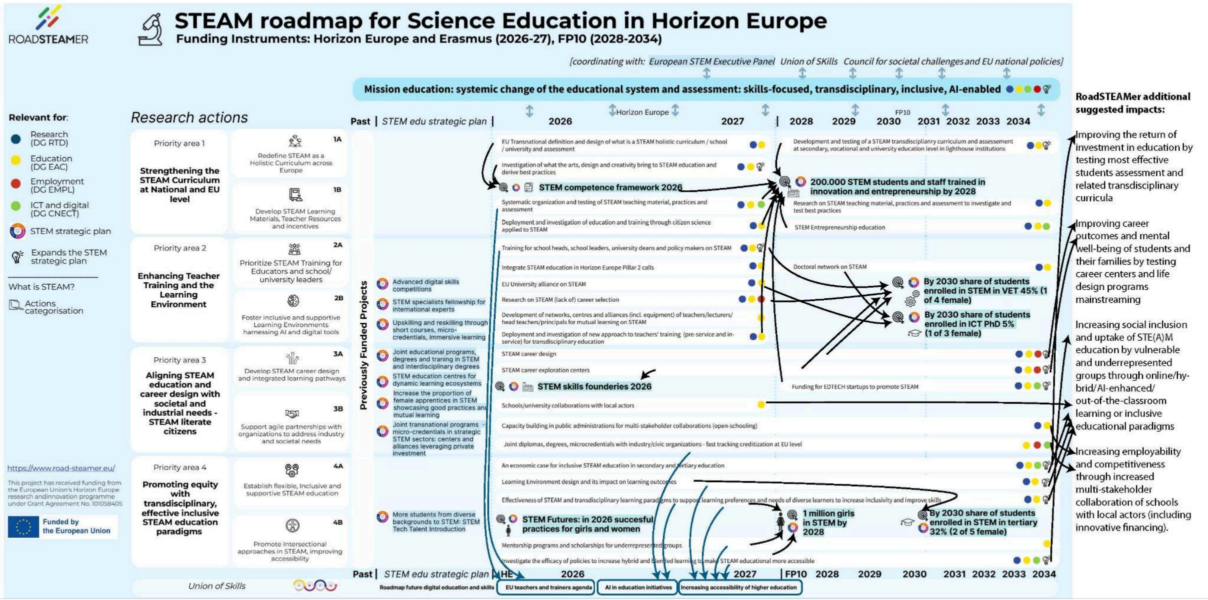

Figure 28: Representation of the expected impact of the 30 actions proposed in Chapter 2 on the objectives of the STEM Education Strategic Plan and Union of SKills, and additional aims proposed by the Road-STEAMer project (right-hand side)

According to the STEM Education Strategic Plan, “the latest PISA (Programme for International Student Assessment) results show a marked decline in some STEM skills as well as in the share of high achievers across the EU. In 2022, approximately 30% of students did not meet basic proficiency in mathematics, up from around 23% in 2018, while 24% of students were below the basic proficiency threshold in science, a deterioration from 22% in 2018. There is a shortage of certain qualified STEM graduates from vocational education and training (VET) and tertiary education” (pg1). EU strategic documents also persistently recognise the gender gap in maths and in the uptake of STEM education. The STEM Education Strategic Plan recognises that “[a]cting to boost STEM skills requires new ambition and action by the EU and by the Member States. The Draghi and Letta reports provide clear recommendations as to where the EU should put its priorities” (pg 1). As a response to this decline in maths results, to the EU need for STEM specialists, the Road-STEAMer roadmap proposes a Mission Education to enable a systemic change of education through coordinated research actions on education, based on changing and harmonizing the assessment system across EU Member states to be skills-based, revising the role of educational institutions as open platforms for collaboration with local stakeholders including parents, companies, civic organizations and public entities to solve real problems and increase students’ motivation, to create an educational ecosystem.

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Social impact

The proposed research actions are deeply rooted in the principle of equity, including gender and all intersectionality, with a particular focus on transforming the education system to be inclusive by design, rather than considering inclusivity as an afterthought, thus offering a range of educational options to cater the need of diverse students including students with physical, cognitive or social disabilities or challenges, language barriers, cultural differences and intersectionality. Priority area 4 "promoting equity with transdisciplinary, effective, inclusive STEAM educational paradigms" is specifically focused on suggesting research actions that can inform the most effective development of digital and physical learning environment to increase equity, inclusion and empowering all students in the uptake of STAM careers. In addition to priority area 4, in all other priority areas, inclusivity is embedded as a core value in all actions, with the purpose of increasing social inclusion and uptake of STE(A)M education by vulnerable and underrepresented groups through online/hybrid/AI-enhanced/out-of-the-classroom learning or inclusive educational paradigms. Beyond the PISA assessment, revised pan-European students' and teachers' assessment should not only measure skills in reading, writing, maths and science, but also include emotional and life skills, entrepreneurship and motivation, with mixed methods that provide qualitative data to understand barriers and moderating variables. As the PISA assessment takes place only for 15 year old students, the comprehensive measurement of students' skills should take place systematically in all EU schools every 2 years from the age of 6 until the end of high school. Such a rich dataset would support researchers and thus policy makers in understanding which policies have a higher societal and economic return on investment.

Economic impact

The research actions proposed in the roadmap are envisioned to have a positive economic impact by:

i) improving career outcomes and mental well-being of students and their families by testing career centers and life design programs mainstreaming,
ii) increasing employability and competitiveness through increased multi-stakeholder collaboration of schools with local actors (including innovative financing).
iii) improving the return of investment in education by testing the most effective students assessment and related transdisciplinary curricula.

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Political impact

The proposed research actions under the Mission Education are expected to generate significant political impact at both the European and Member State levels. By providing a coherent, evidence-based roadmap for systemic change in education, the actions strengthen the political legitimacy of EU interventions in education, a policy area traditionally governed at the national level but increasingly framed within EU competitiveness, cohesion, and digital transitions.

Implementing the proposed research actions could support the consolidation and further development of EU STEM/education policy frameworks—including the Union of Skills, the STEM Education Strategic Plan, the Digital Education Action Plan, and the European Skills Agenda—by offering concrete research-based pathways to operationalize their objectives. In doing so, it enhances the political credibility of these strategies, ensuring they move beyond declarative commitments to actionable reforms backed by empirical evidence.

Second, the roadmap contributes to stronger policy coherence across European Commission Directorates-General, as highlighted by the mapping of each proposed research action to relevant DGs. This coordination would reduce fragmentation, and facilitate coordination in areas such as education, research, employment, and digital transformation.

Third, the Mission Education would provide Member States with a shared long-term vision and set of tools to align national reforms with EU-wide objectives promoting convergence on key challenges such as digital literacy, inclusivity, and competitiveness. Implementing bold actions in education through a Mission Education could increase the EU's global political positioning by demonstrating leadership in reimagining education systems to support the digital and sustainability transitions.

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Conclusions and Recommendations

The document outlines the second and final 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 sections 1.2 to 1.5. This work then fed into a collaborative policy roadmapping co-creation process involving a series of iterative workshops and dialogues with stakeholders. The first version of the roadmap delivered in D5.1 has then been tested in several workshops, events, dialogues and through the online platform, for a total of 21 workshops and events, 5 dialogues and 4 presentations to academic conferences.

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

1. *Strengthening the STEAM curriculum at national and EU level*
   a. redefine STEAM as a transdisciplinary curriculum;
   b. develop transdisciplinary STEAM learning materials and teacher resources;
2. *Enhancing teacher training and the learning environment*
   a. prioritize STEAM training for educators and schools/university leaders;
   b. foster inclusive and supportive learning environments harnessing AI and digital tools;
3. *Aligning STEAM education and career design with societal and industrial needs*
   a. develop STEAM career design and integrated learning pathways;
   b. encouraging agile partnerships with organizations to address industrial and societal needs;
4. *Promoting equity with transdisciplinary, effective & inclusive STEAM education paradigms*
   a. flexible, inclusive and supportive STEAM education;
   b. promote intersectional approaches in STEAM, improving accessibility.

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The resulting roadmap is visually structured in the format of a matrix, as well as a timeline with the above-listed priority areas. Overall, the roadmap contains 30 concrete actions, each detailed with an indication of the most suitable EU funding instruments, tentative timeframe 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, each action also contains a specification on how it relates to the STEM Education Strategic Plan (aligning to it or providing actionable ideas for expansion). In the timeline version of the roadmap, proposed actions are aligned to the milestones and actions of the STEM education Strategic Plan, as well as with the forthcoming strategic documents of the Union of Skills.

Further feedback is currently being collected through a questionnaire that will remain open after the project to collect information on the impact achieved by the project.

In conclusion, 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. To ensure the roadmap can be accessible in the future, the interactive pdf is provided in Zenodo.

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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 D1.1, was to ensure that the project's outputs, and specifically the STEAM roadmap, were 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 project consortium aimed to engage a minimum of 1,500 people 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.

While stakeholder engagement is documented in detail in deliverable 1.3, it is relevant to note here that stakeholder engagement targets have been achieved and exceeded, as demonstrated in the table 2 below.

Table 2. Results of the participatory activities by stakeholder group

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	577
	Formal education learners and families *(school education students and their parents)*	550 school education students	2983
Higher education	Higher education professionals and organisations *(academics, university researchers, other higher education experts, universities, higher education authorities, etc.)*	50 higher education teachers/experts	211

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	Formal education learners *(higher education students)*	250 higher education students	258
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	68
	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	1356
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	696
Creativity and arts	Creative industries professionals and organisations *(designers, content creators, gaming experts, makers, creative industry businesses and institutions, etc.)*	50 creative community members	52
	Artists and arts organisations *(theatre/dance companies, galleries, museums, etc.)*, arts education professionals and institutions		55
Entrepreneurship and business	The world of entrepreneurship and business *(businesspeople, companies, etc.)*	50 world-of-entrepreneurship-and-business members	74
Civil society	Citizens, civil society, NGOs and other third sector actors	100 citizens, third sector organization members	785
Policy making	Education, research and innovation policy makers *(at various levels from local to European)*	50 policy makers at various levels (local to European)	133
TOTAL		**1,500**	**7,248**

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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 six formats:

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
6. Presentation at academic conferences

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). 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, prototyping and testing of the roadmap a total of 21 sessions (events/workshops), 5 dialogues, 4 presentations to conferences, were organized.

For the development of the roadmap (Task 5.2) described in D5.1 and in the deliverable 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 34 participants. They were conducted from July 2024 to April 2025. Specifically the participants belonged to the following groups:

- School education professionals and organisations, specifically special education educators: 2

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- Higher education professionals and organisations: 13
- Formal education learners (higher education students): 34, of which 2 special education needs students
- Informal and non-formal science learning professionals and organisations: 4
- The world of entrepreneurship and business: 11
- Citizens, civil society, NGOs and other third sector actors, specifically disability advocacy organisations: 6
- Education, research and innovation policy makers: 11

For the testing of the roadmap (Task 5.3), which is the specific focus on Section 3 of this deliverable, additional 2 events, 5 workshops, 1 dialogue, 4 presentations to conferences and feedback through the Road-STEAMer online platform have been organized in between April 30th and July 2nd 2025. Specifically the participants belonged to the following groups:

- School education professionals and organisations: 2 special education educators: 37 heads of school
- Higher education professionals and organisations: 53
- Formal education learners (higher education students): 22
- Informal and non-formal science learning professionals and organisations: 10
- The world of entrepreneurship and business: 16
- Citizens, civil society, NGOs and other third sector actors, specifically disability advocacy organisations: 4
- Education, research and innovation policy makers: 44

The wide and diverse set of participants allowed the consortium to gather perspectives from a broad range of education and innovation stakeholders. Further details are reported in the dedicated deliverable D1.3.

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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

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STEAM, but also what is needed to bridge the gap between aspiration and implementation. 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 effective 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

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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

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cannot be reduced to a technical matter of curriculum design or materials provision. It 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

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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.

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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 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,

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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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Appendix F: Testing the roadmap through the participatory platform

A dedicated participatory space was created within the Road-STEAMer platform to collect feedback on the roadmap. Built on Decidim, a free open-source platform for digital participation, the environment enabled collaborative and asynchronous stakeholder engagement.

The space, titled "*STEAM Roadmap for Science Education in Horizon Europe*" with the subtitle "*Provide your feedback and suggestions*", functioned as a Decidim assembly. Its landing page outlined the feedback process and provided instructions on how to participate.

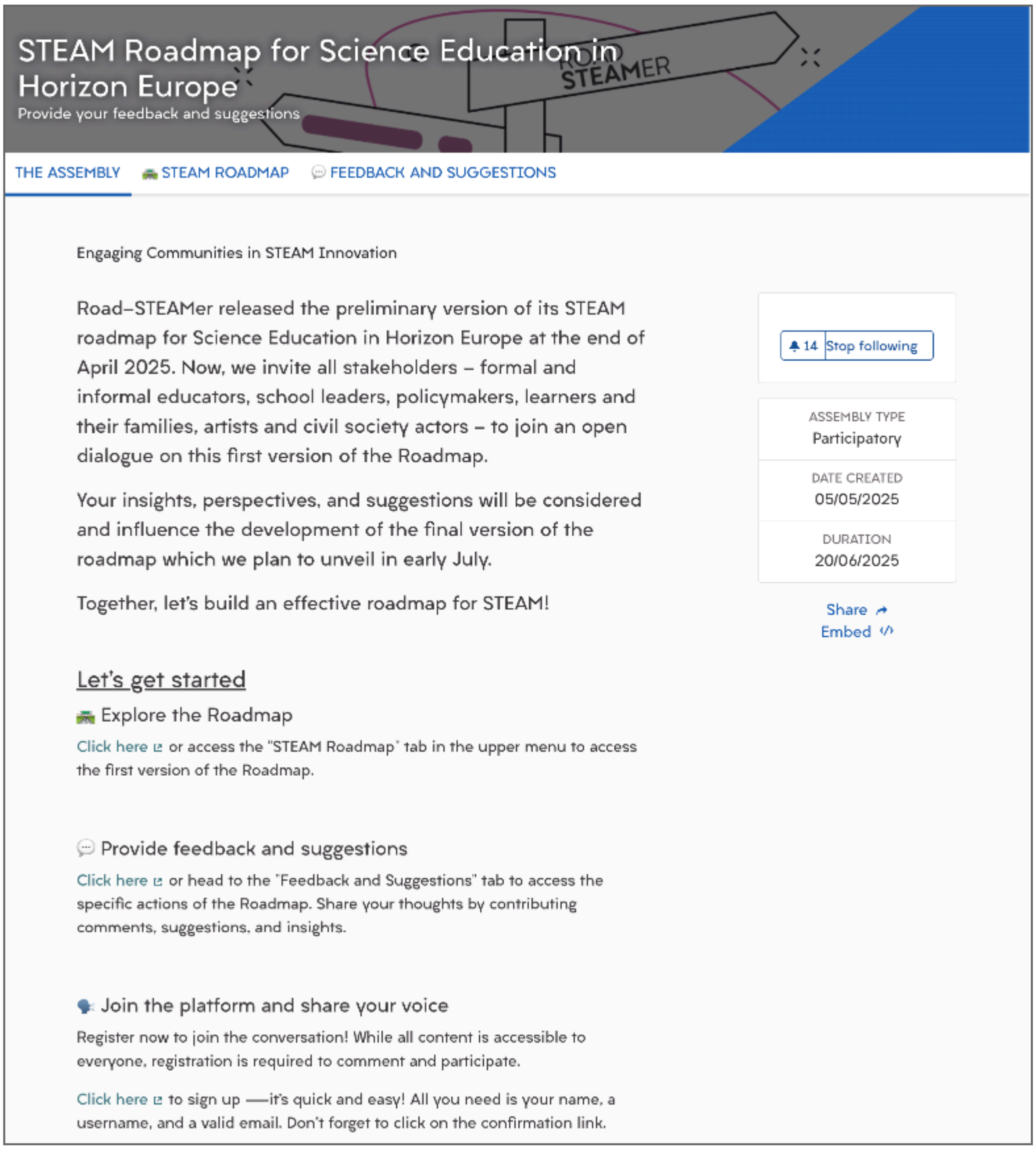

Figure 29: Landing page of the participatory space for roadmap feedback collection

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The space had the following interactive components:

- **STEAM Roadmap**: the roadmap was embedded as an interactive document that participants can navigate.
- **Feedback and suggestions**: based on the Decidim proposals component, each action in the roadmap was presented as a proposal. Participants could endorse proposals to indicate support and/or comment for more detailed feedback. Proposals could be filtered by priority area (category / subcategory) or keyword, and sorted by multiple criteria (e.g. most endorsed or commented). Each action in the Roadmap included a direct link to its respective proposal to provide feedback on it.

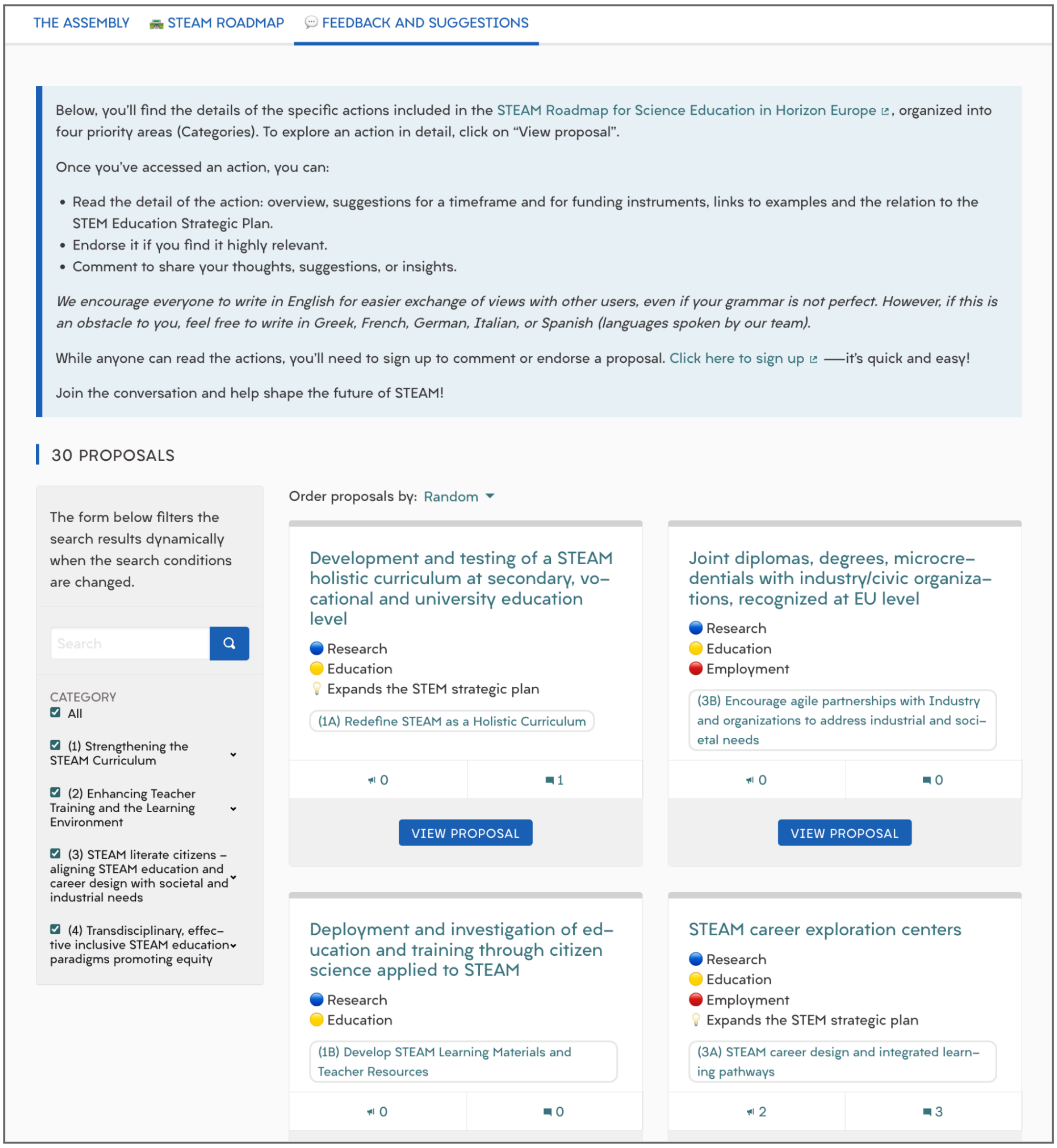

Figure 30: Participatory space with the list of actions available for feedback

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Each action/proposal included the following key details, manually extracted from the original roadmap:

- Areas of relevance;
- Description;
- Examples;
- Potential funding instrument;
- Suggested time frame;
- Alignment with STEM Education Strategic Plan 2025.

The platform recorded nearly 60 interactions, including comments and endorsements, which helped validate the relevance of the proposed actions and surface user-generated insights on feasibility constraints and opportunities for further improving the roadmap.

Specifically, there were 27 endorsements on 20 actions, and 32 comments on 17 actions. Notably, this engagement covered 23 of the 30 total proposals (77%), suggesting broad relevance of the roadmap content.

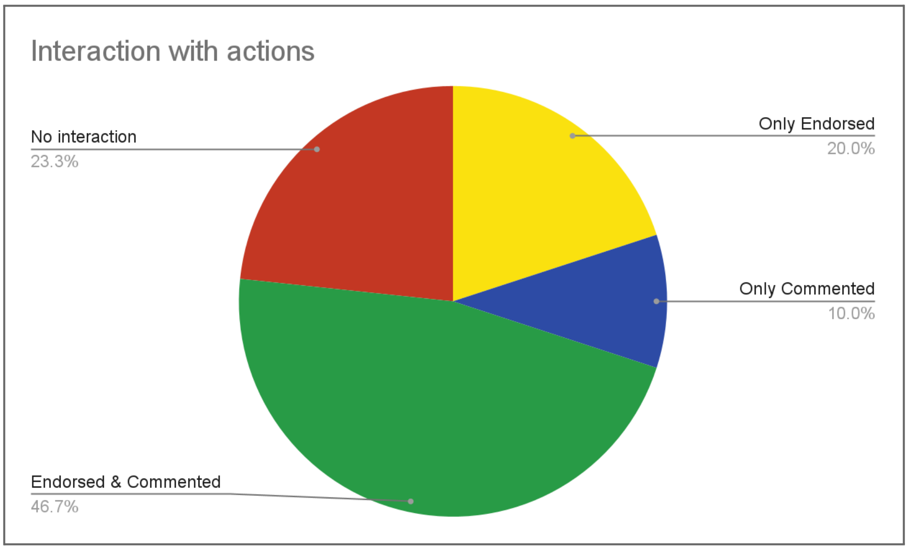

Figure 31: Feedback on actions in the participatory space

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