WP3 Analysis of STEAM policy gaps and needs

Deliverable 3.2 Analysis of policy gaps for STEAM

Deliverable 3.2

Grant Agreement Number	101058405
Project Acronym	Road-STEAMer
Project title	Developing a STEAM Roadmap for Science Education in Horizon Europe
Start date of the project	01/09/2022
Duration of the project	36 months
Due Date of Deliverable	31/08/2024
Lead partner	EA
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Version	1.0
Dissemination Level	Public
Project website address	https://www.road-steamer.eu/

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List of abbreviations

DEAP	European Union's Digital Education Action Plan (2021-2027)
EU	European Union
OECD	Organisation for Economic Co-operation and Development
Road-STEAMer	Horizon Europe project "Developing a STEAM Roadmap for Science Education in Horizon Europe" (project number: 101058405)
STEM	Science, Technology, Engineering, Mathematics
STEAM	Science, Technology, Engineering, Arts, Mathematics
UNESCO	United Nations Educational, Scientific and Cultural Organization

Revision History

Revision	Date	Authors	Organisation	Description
0.1	18/06/24	Pavlos Koulouris, Vasileios Liakopoulos, Petros Stergiopoulos	EA	Table of Contents
0.2	23/08/24	Pavlos Koulouris, Vasileios Liakopoulos, Petros Stergiopoulos	EA	Draft for review
0.3	26/08/24	Elena Silvestrini, Annalisa Addis	LC	Reviewers' comments
		Elisabeth Unterfrauner	ZSI	
		Sabrina Bresciani	PO	
		Kostas Karpouzis	PAN	
0.4	29/08/24	Pavlos Koulouris, Vasileios Liakopoulos	EA	Incorporation of comments, revision and final draft
1.0	30/08/24	Marta Anducas, Annalisa Addis	LC	Formatting and pdf submission

Abstract

This report is deliverable 3.2 (D3.2) of the Road-STEAMer project, titled "Analysis of policy gaps for STEAM". It is the final output of Task 3.2 "Policy gap analysis" within the third work package of Road-STEAMer (WP3 "Analysis of STEAM policy gaps and needs").

The aim of this policy gap analysis is to examine to what extent existing educational policies promote and support effective STEAM education as defined in the Road-STEAMer project, exploring how current educational policy making in Europe relates to STEAM education and its desired characteristics. To this end, the analysis compares a corpus of identified existing policies against desired policy characteristics in three dimensions (STEAM curriculum, STEAM context, and STEAM agenda), and documents any gaps that may exist as well as any opportunities that may emerge. The definition of the desired policy characteristics is based on the characteristics of effective STEAM education as already defined elsewhere in Road-STEAMer (cf. the analysis of STEAM concepts, contexts, and conditions in WP2, and the analysis of the landscape of STEAM practices in WP4).

The policy gap analysis, combining desk research with input from co-creative workshops in line with the overall participatory methodology of Road-STEAMer, draws a distinction between policy making which is directly and explicitly aimed at promoting STEAM education ("STEAM-focused"), and other policy making which may indirectly and implicitly support effective STEAM education even though STEAM is not among the expressed aims and objectives of the relevant policies ("STEAM-relevant").

The main finding is that comprehensive policy making which would promote and support a holistic approach to STEAM is not yet in place. In addition, existing STEAM-focused policy making tends to approach STEAM education too narrowly, overly emphasising STEAM as an instrument for STEM and the promotion of STEM-related goals. However, our analysis also showed that other existing educational policies seem to share common ground with Road-STEMer's vision for STEAM education. As a result, there are considerable opportunities to anchor the efforts for the promotion of a curriculum and appropriate learning environments for effective STEAM education, as well as the efforts for STEAM's contribution to wider societal goals, within these wider educational policy development frameworks.

Therefore, efforts to promote effective STEAM education should both advocate for specific STEAM-focused policies and exploit all available opportunities to use other policy frameworks and contexts as vehicles for STEAM. The message about the potential for positive impact of STEAM approaches on education, and evidence supporting it, should be passed to all agents of educational policy making, from the European, through the national and regional, to the local and institutional level.

In addition, it is important to use funding and support such as through the Horizon Europe and Erasmus+ programmes to promote the translation of European-level frameworks and guidelines for STEAM into national, regional, local and institutional educational policy making with a true, immediate impact on real-life educational contexts, encouraging bottom-up initiatives, all stakeholders' engagement, as well as appropriate educator and professional development.

What is more, there is space for the development of synergies with other international educational policy making agents such as OECD and UNESCO, albeit always keeping European values and European Union's priorities as the driving force.

Based on the results of the policy gap analysis presented in this report, the Road-STEAMer project will subsequently proceed to formulate policy recommendations to tackle the identified gaps (D3.3, due in February 2025). Then, these recommendations combined with other results and insights from the project will feed into the broader Roadmap for STEAM Education in Europe, the final output of the project, to be released by August 2025.

1. Introduction

1.1 About Road-STEAMer

The overall aim of the Road-STEAMer project is to develop a Science, Technology, Engineering, Arts and Mathematics (STEAM) roadmap for science education in Horizon Europe, i.e. 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 Science, Technology, Engineering and Mathematics (STEM) through the use of artistic approaches, involving creative thinking and applied arts (the "A" in STEAM).

The consortium aims to provide Europe with this roadmap, through:

- Collaboration and co-creation with the stakeholder communities of science education, research, innovation and creativity, through intensive exchange, dialogue and mutual learning among them which will produce better knowledge and shared understandings of the relevant opportunities, challenges and needs.
- A bottom-up approach emphasising educational practice and practitioners' agency rather than high-level conceptualizations of STEAM and generic top-down plans (in reality often just vague statements of intention) for its adoption in science education.
- A specific focus on ways to leverage the power of STEAM approaches, as manifested through exemplary cases and best practices, so as to enable a bridging of open science and open schooling which can catalyse an increased impact for science education as a crucial tool for addressing Europe's current scientific and societal challenges.

1.2 About this deliverable

This report is deliverable 3.2 (D3.2) of the Road-STEAMer project. It is the final output of Task 3.2 "Policy gap analysis" within the third work package of Road-STEAMer (WP3 "Analysis of STEAM policy gaps and needs"). Within WP3, this work was preceded by an initial analysis of the policy context for STEAM education (D3.1[1]) and will be followed by the formulation of corresponding policy recommendations (D3.3).

1.2.1 Background overview

The development of the STEAM roadmap for science education in Horizon Europe by the Road-STEAMer project (from now on in this document: "the STEAM Roadmap") is based on the results of three interconnected and complementary strands of research.

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[1] https://www.road-steamer.eu/wp-content/uploads/2024/04/RoadSTEAMer-3.1-Policy-Context-for-STEAM.pdf

The first strand, which corresponds to the foundational work carried out within the second work package of Road-STEAMer (WP2), provided a comprehensive analysis of STEAM concepts, contexts, and conditions, by examining the wider socioeconomic context of STEAM education and relevant needs in Europe (D2.1[2]), developing a comprehensive conceptual framework for STEAM (D2.2[3]), and analysing the conditions and requirements for the effective adoption of STEAM approaches in education (D2.3[4]).

On this background, a second strand of research in Road-STEAMer has focused on the analysis of the landscape of STEAM practices (WP4), defining a research framework reflecting Road-STEAMer's conceptualisation of STEAM (D4.1[5]) to use for the identification of successful STEAM practices (D4.2[6], D4.3[7], and D4.4[8]).

The present document belongs to the third strand of work which will ultimately contribute to the development of the STEAM Roadmap, in which the focus is on policy-related dimensions of STEAM education. Policy analysis in Road-STEAMer (WP3 "Analysis of STEAM policy gaps and needs") is performed in three steps. First, an initial analysis of the wider policy context for STEAM education was carried out (D3.1). On that basis, the second step is an analysis of policy gaps for STEAM, which is concluded through the present report (D3.2). As a third step and based on the results of the previous two steps, the project will subsequently produce policy recommendations for STEAM (D3.3).

The synthesis of all above results for the development of the STEAM Roadmap will be carried out in the context of WP5.[9]

1.2.2 Methodology

The aim of policy gap analysis was to examine to what extent existing educational policies promote and support effective STEAM education as defined in the Road-STEAMer project. We built on the preceding first overview of the policy context for STEAM (D3.1), seeking to gain a deeper understanding of how current educational policy making in Europe relates to

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[2] https://www.road-steamer.eu/wp-content/uploads/2024/01/D2.1-Socio-economic-context-and-relevant-needs.pdf
[3] https://www.road-steamer.eu/wp-content/uploads/2024/02/RoadSTEAMer-D2.2-Concpetual-Framework.pdf
[4] https://www.road-steamer.eu/wp-content/uploads/2024/04/RoadSTEAMer-D2.3-Analysis-of-conditions-and-requirements-for-STEAM.pdf
[5] https://www.road-steamer.eu/wp-content/uploads/2024/01/D4.1_Research-Framework.pdf
[6] https://www.road-steamer.eu/wp-content/uploads/2024/04/RoadSTEAMer-D4.2-The-landscape-of-STEAM-practices.docx.pdf
[7] https://www.road-steamer.eu/wp-content/uploads/2024/07/RoadSTEAMer-D4.3-Report-on-real-life-use-cases.pdf
[8] https://www.road-steamer.eu/wp-content/uploads/2024/08/D4.4-Report-on-Lessons-Learnt.pdf
[9] The remaining work packages of Road-STEAMer support all work carried out overall in the project, through community building and participatory research (WP1), communication, dissemination and exploitation (WP6), and management (WP7).

STEAM education and its desired characteristics. Our policy gap analysis work evolved through the following stages:

- **Defining the scope:** As a starting point of the policy gap analysis exercise, we defined which policies were to be analysed. The identified policies and policy-related documents included those already covered in D3.1, while we also investigated additional ones that emerged during the study as promising for the promotion of STEAM education in Europe and therefore relevant to the development of the Roadmap. The identified policies and policy-related documents are discussed in the relevant section further below (section 2) and summarised in Annex 1.

- **Identifying the desired policy characteristics:** Based on the characteristics of effective STEAM education as defined in the context of WP2 and WP4, we defined dimensions that policies need to align with in order to promote and support effective STEAM education. We used these desired policy characteristics as the dimensions of our policy gap analysis exercise. The policy gap analysis dimensions are presented in the corresponding section further below (section 3).

- **Analysing existing policies:** Building on the previous two stages, we compared the existing policies and policy-related documents against the desired policy characteristics with the aim to identify and document any gaps that may exist. This policy analysis is discussed in detail in section 4 of this report.

The above three stages consisted predominantly in desk research. To complement that and in line with the overall participatory methodology of Road-STEAMer (cf. WP1, D1.1), we informed our policy gap analysis with input from two workshops aiming to produce shared understandings and gain richer insights and evidence from the community. Participants of the first workshop, which was organised in conjunction with a plenary project meeting, were consortium partners. The second workshop was subsequently organised to include consortium partners as well as invited outside experts and practitioners. Materials from the two workshops are included in Annex 2. The discussion during the workshops delved into the definition of the policies that it would be relevant to analyse within the scope of this policy gap analysis, the organisation of the desired policy characteristics into easily usable policy gap analysis dimensions, as well as the core messages emerging from the analysis of existing policies. Input from the workshops is included in all relevant sections of this report.

2. Policy gap analysis scope

2.1 Overview of educational policy making in Europe

Our work for the study of any policy gaps in relation to the aim of promoting effective STEAM education started by defining which policies were to be analysed. Throughout this phase of defining the scope of our policy gap analysis, we aimed to be guided by a clear view of what could and should count as relevant educational policy making within Europe's complex policy systems.

At the European level, the European Union's policy on educational issues is designed to support national education systems and address common challenges.[10] Thus, European educational policy making sets broad frameworks and guidelines aimed at fostering common standards across Member States. However, education remains largely a national competence, allowing individual countries to tailor policies to their specific cultural, economic, and societal needs. While EU policies provide direction and encourage best practices, the implementation and prioritisation of educational initiatives vary significantly at the national level, reflecting each country's unique context and governance structures. This dual approach allows for both cohesion across Europe and flexibility for national adaptation.

At the national level, educational policy making provides the overarching framework and standards for the education system of a country, setting curriculum guidelines, funding allocations, and, more generally, broader objectives. However, regional, local, and institutional levels play a crucial role in adapting these policies to meet the specific needs and contexts of their communities. Depending on the degree of centralisation or decentralisation of each education system, to a greater or lesser extent regional and local authorities often tailor national policies to address local challenges and schools and institutions have the flexibility to implement these policies in ways that best suit their students' needs. Such approaches allow for innovation and responsiveness at the ground level, ensuring that educational practices are relevant and effective within specific contexts, while still aligning with national goals.

Given the broader goal of contributing to the definition of a European-level STEAM Roadmap, as well as given the available resources for this task, our work naturally focused mainly on the European level of policy making. Nevertheless, we also kept a strong interest

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[10] https://commission.europa.eu/education/policy-educational-issues_en

in identifying ways in which the promotion of STEAM education at the European level can reach lower levels of educational policy making, not only through the "bureaucratic" path of the alignment of national strategies with EU guidelines, but especially also through targeted funding initiatives, such as Horizon and Europe Erasmus+. To our understanding, these programmes and their future evolution can incentivise regional, local, and school-level adoption of STEAM practices by providing practitioners and school communities with broad access to best practices, effective training and professional development, coordination of efforts and support. By encouraging collaboration between governments, educational institutions, and industry, European-level initiatives can inspire grassroots changes in everyday educational practices, leading to more creative, inclusive, and problem-solving-oriented educational approaches that directly impact students' learning experiences. In our view, such top-down support, combined with bottom-up innovation, can ensure that STEAM education will become an integral part of the classroom, preparing students for future challenges.

2.2 The analysed policies

An important part of the task of defining which policies were to be analysed in the policy gap analysis was already covered in the preceding phase of WP3. Building on that basis, we studied the policies identified in D3.1[11], while also investigating additional policies that emerged during our study as interesting and promising for the promotion of STEAM education in Europe.

The initial analysis of the policy context for STEAM education (D3.1) explored the intersection of policy making and STEAM education, emphasising the need to integrate arts into STEM fields to address complex societal challenges, fostering interdisciplinary learning and creative thinking as crucial elements for tackling issues like climate change and skills shortages in Europe. That analysis showed that despite the growing broader understanding of the importance of STEAM, educational policies across Europe often still favour STEM, with STEAM being viewed primarily as a means to attract more students. However, Road-STEAMer highlights the necessity for a more holistic and inclusive approach to STEAM, foregrounding elements such as collaboration, creativity, real-world connections, and equity. This contrasts with traditional policy making, which often follows a top-down approach and may overlook grassroots initiatives that address real-life problems.

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[11] https://www.road-steamer.eu/wp-content/uploads/2024/04/RoadSTEAMer-3.1-Policy-Context-for-STEAM.pdf

In this context, the initial policy analysis reported in D3.1 aimed to map the landscape of STEAM education policies at both the EU and national levels, examining how well these policies integrate arts and humanities and assessing the adoption of EU recommendations. The report underscored the importance of both top-down policy initiatives and bottom-up contributions from educators and community leaders in shaping effective STEAM education.

The initial policy analysis drew particular attention to the 2015 "Science Education for Responsible Citizenship" report[12] as a key policy document for promoting STEAM education in the European Union. This report outlines a framework of key areas, including transitioning from STEM to STEAM, enhancing teaching quality, fostering collaboration, and promoting Responsible Research and Innovation (RRI). The provided guidelines aim to systematically transform science education across Europe, including through STEAM, emphasising equity, accessibility, and the inclusion of marginalised groups.

The initial policy analysis reported in D3.1 went on to examine subsequent EU policies, such as the 2018 Recommendation on Key Competences for Lifelong Learning[13], which recognised the need to address societal and digital challenges by integrating STEAM into education. This integration is seen as vital for inspiring youth, particularly women, to pursue STEM careers by combining computational skills with creativity.

Further, work at that early stage identified the 2020 European Commission Communication which further emphasised the importance of aligning EU skills with labour market demands[14], advocating for STEM and STEAM education to cultivate transversal and entrepreneurial skills.

In addition, the initial policy analysis highlighted the Digital Education Action Plan 2021-2027 (DEAP)[15], which emphasises inclusivity and lifelong learning in STEM, with a focus on increasing women's participation. The plan calls for a shift from STEM to STEAM, integrating arts into education to enhance digital skills and ensure equitable access to knowledge. This transition marks a broader EU digital skills policy, positioning STEAM education as a cornerstone of future educational strategies – albeit in the case of DEAP with a narrow focus on attracting more girls and women into STEM.

Beyond the European level, D3.1 also examined how different EU countries have responded to EU recommendations and the extent to which they prioritise STEAM education at the

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[12] https://op.europa.eu/en/publication-detail/-/publication/a1d14fa0-8dbe-11e5-b8b7-01aa75ed71a1
[13] https://op.europa.eu/en/publication-detail/-/publication/297a33c8-a1f3-11e9-9d01-01aa75ed71a1/language-en
[14] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0274&from=EN
[15] https://education.ec.europa.eu/focus-topics/digital-education/action-plan

national level. A notable limitation is that most policies examined only referred to STEM and not STEAM, possibly because the latter term is still less common or does not translate well in the national language(s). In these cases, the analysis in D3.1 used the term "STE(A)M" to indicate policies that do not necessarily adopt the STEAM acronym, while at the same time including some elements that go beyond strictly defined STEM.[16]

The analysis highlighted a varying degree of emphasis on STE(A)M education across the EU, with some countries leading the way with well-developed policies, while others are still in the process of integrating STE(A)M into their educational frameworks. It categorised countries into three groups based on their commitment to STE(A)M education:

- **Countries prioritising STE(A)M education:** These countries, including Belgium, France, Bulgaria, Finland, and Germany, demonstrate consistent and long-term commitment to STE(A)M through comprehensive strategies and action plans. For example, Belgium and Bulgaria have launched national STE(A)M agendas, while Finland and Germany have integrated STE(A)M into broader national policies, emphasising the importance of interdisciplinary education.

- **Countries recognising STE(A)M's importance:** Countries like Austria, Romania, Denmark, Spain, and Italy have recognised the significance of STE(A)M and implemented various initiatives, though these may be more recent or focused on specific areas. For instance, Austria's "Join in STEM" action plan and Romania's new STEM curriculum reflect growing awareness, while Spain and Italy have integrated STE(A)M elements into their education systems.

- **Countries developing or lacking STE(A)M initiatives:** This category includes countries like the Czech Republic, Slovenia, Hungary, and Slovakia, where STE(A)M education is either not a high priority or still in the early stages of development. These countries may have general education strategies that lack specific focus on STE(A)M or are just beginning to implement related initiatives.

Furthermore, the initial policy analysis reported in D3.1 established that countries prioritising STE(A)M education in their policy agendas have adopted various strategies tailored to different audiences. Nations like Belgium, France, Malta, Lithuania, Bulgaria, Finland, and Germany have placed STE(A)M at the forefront of their national policies, setting long-term goals to support sustainable digital and green economies and address inequalities. These

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[16] Later in the present document (cf. section 4.1) we use the term "STEAM-relevant" to characterise policy making which may indirectly and implicitly support effective STEAM education, even though STEAM is not among the expressed aims and objectives of the relevant policies.

countries emphasise STE(A)M education across all educational levels, providing support for professionals, teachers, and broader societal initiatives. National policies such as those of Malta and Estonia have implemented initiatives targeting a wide range of audiences from primary and secondary students to the general public. In contrast, other EU countries, including Italy, Romania, the Czech Republic, and the Netherlands, have focused on educational reform and enhancing digital skills. These efforts often involve project-based learning, partnerships with institutions, and support for teachers, reflecting the evolving role of education post-pandemic as a platform to address societal challenges. In addition, some countries have more specific target audiences: Poland, Croatia, and Greece focus on primary education; Latvia and Lithuania on secondary education; and Austria, Hungary, and Denmark on teachers and STE(A)M professionals, often in response to talent shortages. Finally, addressing social inequalities, particularly increasing the participation of women and girls in STE(A)M, is a central focus for many EU countries, with specialised programmes in place.

Building on this broad background, the current policy gap analysis also looked into the wider frame of current European policy making in the field of education as represented in the European Education Area (EEA),[17] which is the European Union's current broad coordinated initiative to structure collaboration between Member States and stakeholders in order to build more resilient and inclusive national education systems. Our aim was to see whether and how STEAM is currently being envisioned and positioned within the broader European landscape of education and reveal areas of opportunity for the promotion of effective STEAM education within existing and emerging policy initiatives. At the same time, given the overall aim of Road-STEAMer to develop the STEAM Roadmap as a plan of action for science education in Horizon Europe[18], we also looked in more detail into how STEAM is represented within this programme, is the European Union's key funding framework for research and innovation, as well as its predecessor Horizon 2020[19].

Finally, our policy gap analysis work represented a shift from the broad scoping approach of D3.1, which offered a comprehensive overview of multiple policy dimensions relating to STEAM, towards a more focused study of specific aspects that are closely linked to Road-STEAMer's approach to effective STEAM education, providing more detailed insights into specific desire policy characteristics as presented in the following section.

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[17] https://education.ec.europa.eu
[18] https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en
[19] https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-2020_en

3. The desired policy characteristics

The way in which the Road-STEAMer project has defined effective STEAM education provided the framework for identifying the desired policy characteristics, i.e. the priorities that policies need to embrace in order to promote and support STEAM.

3.1 Effective STEAM education characteristics

In earlier stages preceding the policy gap analysis, the project had defined the characteristics of effective STEAM education. Specifically, a thorough analysis of the socio-economic context and need for STEAM (D2.1[20]) had been conducted, a comprehensive conceptual framework and a set of criteria for the analysis of STEAM practices had been defined (D2.2[21] and D4.1[22]), and the conditions and requirements for the effective integration of STEAM in education had been extensively analysed (D2.3[23]). Details of this background work can be found in the relevant deliverables. Here we are highlighting the most important aspects to help frame the policy gap analysis work presented in this document.

At the outset of the project, WP2 provided an initial analysis of the wider socioeconomic context and needs for STEAM education in Europe (D2.1). The key findings and recommendations produced are summarised in Table 1 below.

Societal needs	Barriers of STEM	Benefits of STEAM	Recommendations
1. More scientists	- Science is perceived as difficult - Not all schools offer STEAM subjects	- More emotional, appealing and fun by including arts - Value 'Art' as a way of enhancing self-confidence and facilitate the development of personal opinions and critical thinking - STEAM as a way to break down STEM stereotypes	- More research on STEAM education effectiveness (Arts in addition and/or integrated with STEM) - Make science learning inclusive and appealing: teachers have STEAM easy-to-use material - Communicate to schools and teachers the values of the STEAM approach - Expose students to science careers from the early years - Expose students to science role models from primary years - Value STEAM approach: supporting young people to bring these subjects together, a holistic and subject integrative view is necessary.

[20] https://www.road-steamer.eu/wp-content/uploads/2024/01/D2.1-Socio-economic-context-and-relevant-needs.pdf
[21] https://www.road-steamer.eu/wp-content/uploads/2024/02/RoadSTEAMer-D2.2-Concpetual-Framework.pdf
[22] https://www.road-steamer.eu/wp-content/uploads/2024/01/D4.1_Research-Framework.pdf
[23] https://www.road-steamer.eu/wp-content/uploads/2024/04/RoadSTEAMer-D2.3-Analysis-of-conditions-and-requirements-for-STEAM.pdf

Societal needs	Barriers of STEM	Benefits of STEAM	Recommendations
2. Alignment of industry and societal needs with education	- Provides only technical skills but organisations need workers with soft skills and intercultural abilities	- Arts integrated in STEM courses promote intercultural and collaborative skills - Real world problems are multidisciplinary by default	- Open schools (and other real-world approaches) - Data on industries and organisations' needs are used to support education policies - Project-based collaborative learning to develop soft skills and inclusivity - Multidisciplinary and interdisciplinary projects - Support entrepreneurship and self-employment
3. More diversity (gender, ethnic, socioeconomic, etc.)	- Science career is perceived as not in line with identity of women and minorities	- Arts subjects are more appealing and relatable for diverse people - Diversity improves organisational outcomes	- Policy to affect structural changes (inclusion, access, diversity,…) - Address gaps in abstract thinking/maths from the primary school years - Replace the leaky pipeline metaphor with epistemic justice - Role models to redefine identities and change culture - Include families to change science stereotypes - STEAM focused career training - More research on moderating factors and career paths to optimise policies (e.g. family's attitude, education and career choices, engagement, parents' STEM experience) - Analyse the impact of national differences in school systems
4. Increase science literacy and arts literacy for all[24]	- Science is perceived as difficult or there is lack of awareness	- STEAM as a way to break down STEM stereotypes - Match hard topics with arts to lower perceived barriers and increase interest	- Better connection between the needs of the labour market and lifelong learning - Provide sufficient professional development and training of educational professionals - Develop digital literacies (note 'literacies' instead of 'literacy') beyond computer science - Focus on societal challenges and real problems to promote interest in science - Integrate the need for scientific thinking also in non-scientific/arts topics - Acknowledge the imbalance of financial support for 'Arts' and how these issues could be re-addressed in STEAM - Promote positive attitudes towards STEAM

Table 1: Analysis of the socio-economic context and needs for STEAM education (from D2.1)

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[24] The initial formulation in D2.1 "science literacy for all" was in subsequent stages of the project replaced by "science literacy and arts for all" to signify an equal footing for STEM and Arts in STEAM.

In addition, work carried out in parallel in WP2 and WP4 produced a solid basis for the conceptualisation of STEAM education in Road-STEAMer, in the form of a comprehensive conceptual framework for STEAM and corresponding criteria for the analysis of STEAM practices. The conceptual framework (D2.2) identified four groups of approaches to STEAM:

- Experiential, real-world interaction approaches
- Human psychological and cognitive approaches
- Social, spatial and material interconnectivity approaches
- Cultural and equity approaches.

In connection with this conceptual analysis, the project also developed a set of criteria for mapping and analysing STEAM practice (D4.1). These criteria, which have since significantly influenced all aspects of work in the project, are presented in summary in Table 2 below.

Criterion	Description
Collaboration	Encompassing students' teamwork, connection and dialogue among educators, as well as meaningful collaboration with stakeholders within the school and external actors. In STEAM, teachers are not top-down lecturers, but facilitators, advisors, counsellors, and guides.
Disciplinary Inter-relationships	There cannot be STEAM if disciplines work in silos. The degree of inter- or trans-disciplinarity can vary, from making connections between different subjects, to encouraging knowledge transfer across disciplines with a focus on problem-solving and use of technology.
Thinking - Making - Doing	Highlighting the interconnectedness of thinking, making, and doing within STEAM practices, contributing to a holistic and dynamic learning experience.
Creativity	A fundamental component of STEAM activities, associated with innovation and the generation of novel ideas and outcomes, and linked to playfulness. Creativity can be simultaneously a process and a product of STEAM practices, as these encourage creative thinking. In activities such as those featuring digital technologies and design, creativity is not limited to the thinking aspect but extends to doing.
Real-world Connection	Anchoring learning in real-world contexts, often tackling contemporary and complex issues like the climate crisis and civic engagement. Problem-solving and inquiry-based learning can provide a sense of authenticity and purpose, empower learners to see themselves as change-makers, and foster entrepreneurship.
Inclusion - Personalisation - Empowerment	Designing activities in which all participants, regardless of their confidence levels, can fully engage. STEAM provides a context for young people to develop their identities and see STEAM as a domain for them. The emphasis on personalization and empowerment contributes to a more inclusive and engaged learning environment.
Equity	An underlying value that should permeate all STEAM practices and transcends all of the above core criteria. It emphasises fairness and inclusivity in the design, processes, and outcomes of STEAM education.

Table 2: Criteria for mapping and analysing STEAM practice (based on D4.1)

On this background, further work carried out within WP2 explored the real-life conditions, requirements, challenges and opportunities linked to the effective integration of STEAM into everyday educational practice in Europe's schools, focusing on aspects such as the curriculum, teachers and their training and professional development, school organisation and leadership, and characteristics of educational systems (D2.3).

This analysis produced a comprehensive list of conditions and requirements for the integration of STEAM in today's education, ranking them roughly from the most to the least difficult to achieve. Based on the logical assumption that policies should prioritise addressing the most challenging of these conditions and requirements, in the policy gap analysis we focused on the red area of the "traffic light" colour scheme adopted in D2.3, which represents the most difficult conditions covering the top one third of the ranked list. As a result of background work that was carried out at the start of our policy gap analysis exercise, Table 3 below presents a summarisation of some of the most challenging conditions and requirements for the integration of STEAM in education.

Area	Condition for STEAM
Curriculum frameworks	- Curriculum flexibility allowing for innovative practices - Teachers making independent teaching and assessment choices, within general curriculum frameworks and guidelines
Learning and assessment	- STEAM practices that foster collaboration among students, teachers, and actors from outside school - Learning assessment practices that go beyond traditional testing, to cover aspects such as student engagement, collaboration, wider competence development
School structure and organisation	- Availability of time within the core school schedule - Possibility to use time flexibly within the core school schedule (e.g. restructuring the schedule) - Possibility to use time outside the core school schedule - Availability of financial resources - Budget flexibility to adapt to emerging needs
School climate and culture	- Encouragement of collaboration across disciplines and curriculum areas - All disciplines valued equally, ensuring equitable access to opportunities and resources - A culture of ongoing evaluation towards continuous improvement
School leadership	- School leadership supportive of innovative educational practices - Visionary school leadership proactively creating the conditions for the integration of STEAM

Area	Condition for STEAM
	- Long-term planning and commitment supporting the sustainability and scalability of STEAM innovation in the school - School leadership shifting from top-down approaches to a collaborative vision of distributed leadership roles and shared decision-making - School leadership trusting teacher autonomy and initiative
Teachers and their training and professional development	- Teacher's familiarity with other areas of the curriculum beyond their own main area(s) of expertise - Teacher's freedom to decide and act autonomously - Teacher's role as a change agent, actively driving positive change in education - In-service professional development tailored to teacher's individual needs

Table 3: Some of the most challenging conditions and requirements for the integration of STEAM practices in education (based on D2.3)

Overall, the rich background work that we briefly summarised above provided a broad framework for a well-grounded understanding of effective STEAM education. This formed the foundation on which we defined the desired policy characteristics, as discussed in the following section.

3.2 The policy gap analysis dimensions

For the needs of the policy gap analysis, we translated the above characteristics of effective STEAM education into desired policy characteristics, i.e. aspects that policies need to prioritise in order to promote and support STEAM. Our aim was to formalise the desired policy characteristics into a concise set of dimensions that would be used as the conceptual tool for the comparison of the existing policies against the desired policy characteristics[25].

The set of policy gap analysis dimensions was gradually defined and agreed through discussion within the consortium as well as interaction with outside experts and practitioners. It resulted from a combination of desk research (consisting mainly in critical cross-reading of the preceding deliverables and logical organisation and synthesis of the emerging concepts) with elaboration of successive drafts of the list of policy gap analysis dimensions in the two policy gap analysis workshops. The evolution of the set of policy gap analysis dimensions is briefly summarised in Annex 3.

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[25] In earlier stages of our work, we used the term "policy gap analysis criteria". Based on feedback from the workshops, we eventually changed this into "policy gap analysis dimensions" to avoid any ambiguity resulting from the already established use of the word "criteria" in Road-STEAMer for the analysis and mapping of STEAM practice.

The final set of dimensions we eventually used for the policy gap analysis is presented in Table 4 below.

Dimension	Explanation
1. STEAM curriculum	Curriculum for effective STEAM education. Special focus on: - Including both <u>science</u> literacy and <u>arts</u> literacy - Aspects corresponding to the criteria for analysing STEAM practice (<u>Collaboration</u>, <u>Disciplinary Inter-relationships</u>, <u>Thinking-Making-Doing</u>, <u>Creativity</u>, <u>Real-world Connection</u>, <u>Inclusion-Personalization-Empowerment</u>)
2. STEAM context	Learning environments for effective STEAM education. Special focus on: - Conditions and requirements for STEAM relating to schools (as well as higher education and non-formal/informal learning spaces) as <u>strong learning environments</u> (autonomy, flexibility, collaboration and innovation-friendliness in organisational climate, culture, structure, leadership) - Conditions and requirements for STEAM relating to educators' (including headteachers') <u>appropriate training and professional development</u>
3. STEAM agenda	Goals and contributions of effective STEAM education. Special focus on: - STEAM for the alignment of educational outcomes with <u>societal needs</u> (development of competencies for life and citizenship) - STEAM for the alignment of educational outcomes with <u>industrial needs</u> (development of competencies for work and employability, uptake of STEM/STEAM careers) - STEAM for <u>diversity and equity</u> (education relevant and inclusive for all, comprehensively covering gender, ethnic, socio-economic, ability aspects)

Table 4: The policy gap analysis dimensions

The development of the set of policy gap analysis dimensions was a rich and challenging task, as it sought to transcend and map diverse concepts and focal points that had been touched upon in the preceding phases of the Road-STEAMer project. Overall, we gradually moved from a more complex to a more summative and integrative organisation of the dimensions, attempting to strike the right balance between giving adequate nuance and keeping the set of policy gap analysis dimensions practical and easy to use. During our analysis and co-creative work at the workshops we explored several different possibilities for organising the core concepts of STEAM; we acknowledge that at deeper levels of analysis and conceptualisation cross-cutting elements and overlaps may be revealed. For instance, one of our attempts to a greater degree of synthesis of the cross-cutting policy gap analysis dimensions is their organisation into axial and transversal, as depicted in Figure 1.

Transversal dimensions

STEAM agenda - Goals of STEAM

	Alignment with societal needs	Alignment with industrial needs	Diversity and equity
STEAM curriculum			
STEAM context			

Axial dimensions (vertical label)
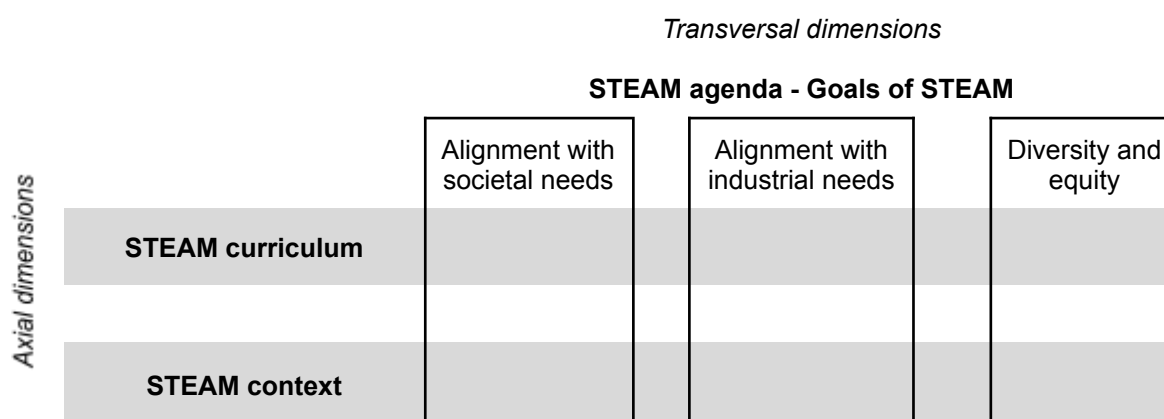
Figure 1: Cross-cutting policy gap analysis dimensions

Nevertheless, it should be noted that the policy gap analysis dimensions are not intended as strict, mutually exclusive analysis tools. Rather, they help us deal comprehensively with the complexity of the landscape of existing and desired policy making for the promotion and support of STEAM education. By using the different policy gap analysis dimensions, we can deal with the various aspects of the broad, multifaceted area that STEAM is, within the educational policy landscape, which itself is a broad, multifaceted field. At the same time, this *meta*-organisation of the STEAM concepts and aspects highlighted by Road-STEAMer may well prove useful beyond the immediate context of policy gap analysis, in other work strands in the remainder of the project.

4. Analysis of the existing policies

Building on the work presented in the previous two sections, we subsequently compared the identified existing policies (section 2) against the desired policy characteristics reflected in the policy gap analysis dimensions (section 3), with the aim to identify and document any gaps that may exist. This involved closely reading the available policy documentation with a special focus on each of the three policy gap analysis dimensions (1. STEAM curriculum; 2. STEAM context; 3. STEAM agenda) and their sub-dimensions. In this section we are concisely presenting our findings.

4.1 Policy making for STEAM education: STEAM-focused vs STEAM-relevant

In our exploration of the field of policy making for STEAM, a distinction soon emerged between policy making which is directly and explicitly aimed at promoting STEAM education ("STEAM-focused"), and other policy making which may indirectly and implicitly support effective STEAM education, even though STEAM is not among the current expressed aims and objectives of the relevant policies ("STEAM-relevant"). In addition, a central consideration in our analysis was related to the question whether any STEAM-focused or STEAM-relevant policies we identified could be considered as conducive to promoting or supporting STEAM education in the holistic way as conceptualised by Road-STEAMer.

4.2 Policy making explicitly for STEAM education

STEAM approaches are not unknown to the educational policy context that we studied. It could be argued that especially some (but importantly, not all of the) aspects of the policy gap analysis dimension relating to STEAM curriculum are well documented in existing policies. This is discussed in the following subsection.

4.2.1 STEAM-focused policy making and STEAM curriculum

STEAM is generally represented in existing policies as an integration of arts into STEM education which is aimed, predominantly, at making STEM more appealing, and fostering creativity and innovation. For instance, in the context of the Horizon Europe programme (within which the Road-STEAMer project is also being funded), STEAM is described as a way "*to encourage more interest in STEM through the use of artistic approaches, involving creative thinking and applied arts (the "A" in STEAM)*"[26].

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[26] https://cordis.europa.eu/programme/id/HORIZON_HORIZON-WIDERA-2021-ERA-01-70/en

However, the nature and curriculum of STEAM, at a deeper level, remains largely undefined or vague in policy texts, with the arts often implicitly or explicitly seen merely as a tool at the service of STEM. This is not aligned with Road-STEAMer's focus on the notion of an effective STEAM curriculum emerging from the inclusion of both science literacy and arts literacy as equal and complementary priorities. Policy making at the European level clearly places a strong emphasis on science education, while the same does not appear to be true for arts education. European Union texts on arts education are less common, as we only managed to trace a report on arts and cultural education at school in Europe from 2009[27] and a relevant briefing of the European Parliament from 2017[28]. In Horizon Europe, too, calls relating to arts in education are not frequent (e.g. HORIZON-CL2-2024-TRANSFORMATIONS-01-08: Arts and cultural awareness and expression in education and training[29]). On the contrary, science education and STEM education, with the two terms often used interchangeably or complementarity to each other, have featured as important dimensions of European policies in the field of education in at least the two last decades (e.g. the 2007 Rocard Report[30], the 2015 "Science Education for Responsible Citizenship" report[31], the Digital Education Action Plan[32]).

Overall, in line with the preceding work reported in D3.1[33], our study confirmed that STEM is still the dominant term, often reflecting a misconception that STEAM is just a rebranding of STEM rather than a different concept aimed at holistically understanding of education and addressing societal challenges. As a workshop participant pointed out: *"Some existing policies mention STE(A)M but reflect a STEM understanding e.g. the EU manifesto for gender inclusive STE(A)M"*.[34]

In other words, our study revealed that policy making has not yet fully realised the transformative powers of more ambitious STEAM approaches such as the one adopted by Road-STEAMer. Both our study of the current policy documentation and the collected views and experience of workshop participants clearly indicated that there is ample space for reflecting a more visionary and more specific STEAM approach in policy making, which would advocate for breaking down traditional disciplinary boundaries and fostering holistic

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[27] https://ec.europa.eu/commission/presscorner/detail/en/MEMO_09_448
[28] https://www.europarl.europa.eu/RegData/etudes/BRIE/2017/608807/EPRS_BRI(2017)608807_EN.pdf
[29] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl2-2024-transformations-01-08
[30] https://op.europa.eu/en/publication-detail/-/publication/5e745fa8-d837-4d9d-bdb0-dd13701c1d81
[31] https://op.europa.eu/en/publication-detail/-/publication/a1d14fa0-8dbe-11e5-b8b7-01aa75ed71a1
[32] https://education.ec.europa.eu/focus-topics/digital-education/action-plan
[33] https://www.road-steamer.eu/wp-content/uploads/2024/04/RoadSTEAMer-3.1-Policy-Context-for-STEAM.pdf
[34] https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/towards-manifesto-gender-inclusive-steam-education-and-careers-2022-10-17_en

learning, helping students tackle real-world challenges in complex, interdisciplinary ways corresponding to the complexities of today's world, creatively and resourcefully adapting to change. In such an approach, the arts should not merely be an add-on to STEM but an integral part of STEAM.

Nevertheless, it should also be noted that some national level policy implementations and bottom-up practices reported in D3.1 offer useful insights into the directions that policies could follow to promote and support more holistic approaches to STEAM. Interesting examples include the "Arts and Science across Italy" programme[35], which promotes collaboration between scientists and artists resulting in the creation of artistic compositions inspired by scientific topics of their choice; senior high schools in Denmark offering STEAM-specific courses in areas such as aquaculture and video game design; countries such as Bulgaria, Belgium, and Finland emphasising the importance of art in STEM education as part of their policy objectives; Malta's latest policy explicitly recognising STEAM and more interdisciplinary approaches.

The example of the UK policy advocacy discourse also offers some useful insights, as there is a strong emphasis on creative education and art-rich schools, where adding the 'A' of arts to the STEM subjects will enable the arts to fulfil their role in developing pupils' ability to innovate and think creatively in the sciences, technology, engineering, and mathematics (cf. Cultural Learning Alliance[36]). As a workshop participant remarked, *"while there is no direct STEAM policy making In the UK apart from the CLA report in 2017, if you match together the STEM and the Arts policy documents you could see how a STEAM policy could emerge between them"*.

4.2.2 STEAM-focused policy making and STEAM agenda

In the existing STEAM-focused policies, our analysis generally traced elements of the "STEAM agenda" dimension. On the one hand, in line with the discussion of a narrow definition of STEAM in the previous section, addressing some of STEAM's goals is evident through the instrumental use of STEAM as a way to improve STEM and therefore respond to social and industrial needs through the development of skills and eventually the uptake of STEM careers.

On the other hand, in existing STEAM-focused policies we also traced a significant interest in the promotion of some aspects of equity, which is a fundamental element of effective STEAM

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[35] https://artandscience.infn.it/
[36] https://www.culturallearningalliance.org.uk

education as defined by Road-STEAMer. Indeed, addressing equity-related issues is reflected in the strong emphasis of existing STEAM-focused policies on using STEAM to make STEM disciplines more appealing to girls and women. For instance, the Digital Education Action Plan 2021-2027 (DEAP)[37], which refers to STEAM in its Action 13, sees the inclusion of the "A" of arts and creativity in STEM as instrumental towards improving women's participation in STEM who are chronically underrepresented in these fields. In addition, the recent initiative towards a manifesto for gender-inclusive STE(A)M education and careers[38] sharply focuses on gender issues, clearly positioned within the landscape of efforts to address the shortage of women in Science, Technology, Engineering and Mathematics fields. In Horizon Europe work programmes and calls, too, STEAM is predominantly linked to addressing the underrepresentation of women in STEM fields (e.g. HORIZON-CL2-2023-HERITAGE-01-08: Cultural and creative approaches for gender-responsive STEAM education[39]).

However, this is a narrow approach to equity and diversity which falls short of Road-STEAMer's interest in making STEAM education relevant and inclusive for all, comprehensively covering gender, ethnic, socio-economic, ability aspects. It is required to shift the focus of policy making for STEAM to fostering better inclusivity not just across the gender spectrum but also to incorporate race, disability and intersectionality.

4.2.3 STEAM curriculum, context and agenda – all combined?

Even if some of the aspects of the STEAM curriculum and agenda dimensions of our analysis could be traced in the existing policies, it also became evident that STEAM-focused policy making remains far apart from defining the STEAM approach in more holistic ways that would encompass all three dimensions of STEAM curriculum, context and agenda and at least some of their sub-items. In other words, STEAM-focused policy making integrating all or several aspects of effective STEAM education as defined by Road-STEAMer has yet to be developed.

It is also important to note that, as workshop discussions revealed, there is a strong feeling among experts and practitioners that the implementation of such a holistic approach to STEAM may not be expected to take place outside wider educational reforms that are needed in the context of changing needs and emerging challenges characterising today's

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[37] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0624
[38] https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/towards-manifesto-gender-inclusive-steam-education-and-careers-2022-10-17_en
[39] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl2-2023-heritage-01-08

world. To use workshop participants' words: *"STEAM is simply not present within the educational system"*, and *"Only by redefining education can you do STEAM properly. If we only insist on STEAM as a separate "something", then it may not affect the way most classes are run"*.

4.3 Policy making conducive to effective STEAM education

Nevertheless, our analysis identified a number of existing policies with significant potential to promote or support different aspects of effective STEAM education as defined in Road-STEAMer, although they are not explicitly STEAM-focused. This is an important finding of our work, as it highlights opportunities for promoting and supporting effective STEAM education by using broader existing policy frameworks as vehicles for STEAM.

4.3.1 STEAM-relevant policy making and STEAM curriculum

In the discussion in section 4.2 above, it became evident that policy making has not yet approached STEAM holistically, especially as far as a STEAM-focused curriculum is concerned. However, the sub-dimensions of an effective STEAM curriculum identified by Road-STEAM are fully compatible with several of the priorities and elements of wider educational conceptualizations and policies. Therefore, even if holistic STEAM-focused policy is still to emerge, the promotion and support of an effective STEAM curriculum could be linked to wider movements within the current educational policy landscape.

An essential constituent of Road-STEAMer's conceptualization of curriculum for effective STEAM education is the equal focus on science literacy and arts literacy. Our analysis of international policy making in the field of education revealed that the relatively weaker policy discourse on arts (in) education in the European Union (as compared to the stronger focus on science and STEM education) could be enriched through interaction and dialogue with relevant work that is being carried out in countries such as the UK[40], or in international contexts such as UNESCO.[41]

In addition, the desired STEAM curriculum aspects corresponding to Road-STEAMer's criteria for analysing STEAM practice (Collaboration, Disciplinary Inter-relationships, Thinking-Making-Doing, Creativity, Inclusion-Personalization-Empowerment, Real-world Connection) are widely accepted notions in current educational thinking and practice. For instance, it would be difficult to locate an educational policy that would not recognise the

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[40] https://www.culturallearningalliance.org.uk
[41] https://www.unesco.org/en/articles/what-you-need-know-about-culture-and-arts-education

paramount importance of collaboration, and a curriculum that actively promotes it, in educational settings. To mention just one example, the importance of developing collaboration skills is ubiquitous in the European Union's discourse on key competences for lifelong learning.[42]

More generally, the holistic STEAM curriculum approaches favoured by Road-STEAMer are largely aligned with the European Union's wider conceptualisations of the desired characteristics of education today. The connections and interrelations between previously separated, siloed areas of knowledge, competence and practice that are implied in Road-STEAMer's criteria such as "Disciplinary Inter-relationships", "Thinking-Making-Doing", "Creativity" and "Real-world Connection" are reflected in the comprehensive approach to EU's key competences for lifelong learning as adapted in 2018 (Figure 2). The relevant recommendation of the Council of the European Union identifies eight key competences (*Literacy competence, Multilingual competence, Mathematical competence and competence in science, technology and engineering, Digital competence, Personal, social and learning to learn competence, Citizenship competence, Entrepreneurship competence, and Cultural awareness and expression competence*) as essential to citizens for personal fulfilment, a healthy and sustainable lifestyle, employability, active citizenship and social inclusion.

Indeed, our reading of this policy framework and our discussions with experts and practitioners showed that the European framework for key competences for lifelong learning can be effectively used to promote STEAM education, if the argument for STEAM aligns the desired core dimensions of STEAM with the principles and elements of the framework. It could be argued that the European framework for key competences for lifelong learning provides a foundation for interdisciplinary and creative STEAM approaches and the design of STEAM curricula that prepare students for personal fulfilment, active citizenship, and employability, ensuring learners are equipped with the competences needed for future challenges. Such as alignment would also help integrate STEAM education into national policies. Nevertheless, as participants in workshop discussions emphasised, even if several or even all of the desired STEAM curriculum aspects are already supported by wider policy frameworks such as the key competences for lifelong learning, turning these visions and priorities into practice remains one of the most significant challenges for the integration of STEAM in education, with relevant obstacles linked to the common difficulties of moving from abstract policy to implementation, resistance to change, time and resource constraints, or even the misalignment of the stated objectives with what is part of the learning assessments.

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[42] https://op.europa.eu/en/publication-detail/-/publication/297a33c8-a1f3-11e9-9d01-01aa75ed71a1/language-en

Figure 2: A visual representation of EU's comprehensive approach to key competences for lifelong learning

In relation to the sub-dimension of creativity, in particular, there also seems to be ample space for interaction of any policy-related efforts to promote and support effective STEAM education through with OECD's work on creative thinking in the framework of the Programme for International Student Assessment (PISA). The current momentum should be considered as an opportunity, as OECD has recently published results from the PISA 2022 Creative Thinking assessment[43], i.e. its latest measurement of students' capacity to engage productively in the generation, evaluation and improvement of ideas that can result in original and effective solutions, advances in knowledge, and impactful expressions of imagination.

At this point, it should be more generally noted that OECD, through its Directorate for Education and Skills[44], provides policy analysis and advice on education to help individuals and nations to identify and develop the knowledge, skills and values that drive better jobs and better lives, generate prosperity and promote social inclusion. Several of OECD's areas

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[43] https://www.oecd.org/en/topics/sub-issues/creative-thinking/pisa-2022-creative-thinking.html
[44] https://www.oecd.org/en/about/directorates/directorate-for-education-and-skills.html

of study and policy advice relating to education and skills[45] could offer opportunities for support in the elaboration of policies at the European and national levels within the European Union aiming to promote and support curricula for effective STEAM education. As discussions at the policy gap analysis workshops confirmed, there is potentially much to learn from such work by OECD, provided of course that the leading values, principles and priorities in this cross-fertilisation will remain rooted in the values, principles and priorities of the European Union. According to a workshop participant's cautionary remark, *"the 'E' in OECD stands for 'Economic', not 'European', and we should be careful in the ways we use their work"*.

Finally, further interesting ideas about how to use current educational movements and priorities to promote effective STEAM emerged during the workshops. Participants underscored the importance of using some of the prevailing practical approaches in education as vehicles for STEAM, as they are compatible with STEAM and offer concrete ways to make the difficult step from theory to practice. Interesting examples are the integration of makerspaces and making activities into the curriculum, and giving students full control of their learning. As a participant noted: *"Utilise makerspaces across the curriculum. And, like in Finland, let the children choose an overall subject they love and build the school curriculum to enhance this. Let students' ideas rule! Entrepreneurial learning at the heart of every day, with students engaging in society and seeing the outcome."*

With reference to makerspaces, it is worth noting the work that the Joint Research Centre (JRC) of the European Commission has carried out on Makerspaces for Education and Training.[46] The relevant report explores the long-term potential that makerspaces and making activities can bring to education and training in Europe. Through developing four scenarios with an outlook to 2034, the report supports anticipatory thinking and helps policymakers, makers and educators to better envision and debate the added value that makerspaces and making activities can offer for education and training in Europe. Including STEAM as an explicit dimension in this and other related discourse spaces would be beneficial both for the purpose of promoting and supporting effective STEAM in Europe and for the respective policy development frameworks, as the question of promoting STEAM practice would help bring more focus on practical aspects of implementation such as monitoring and assessment.

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[45] https://www.oecd.org/en/topics/policy-areas/education-and-skills.html
[46] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC117481/makerspaces_2034_education.pdf

4.3.2 STEAM-relevant policy making and STEAM context

In the case of policy making aiming to secure the appropriate context for STEAM, too, our analysis revealed that despite the lack of relevant STEAM-specific policies there are several educational existing policy approaches and frameworks which are conducive to creating the necessary conditions for STEAM within strong learning environments and led by appropriately prepared educators.

Strong learning environments

As Road-STEAMer has shown in previous stages, implementing effective STEAM education in schools, as well as higher education institutions and non-formal/informal learning spaces, requires creating the conditions for strong learning environments to emerge. The requirements for this, including autonomy, flexibility, collaboration and innovation-friendliness in organisational climate, culture, structure, leadership, are very relevant in many wider policy making frameworks, which could be exploited to promote and support effective STEAM education.

The focal area of improving quality in education and training in the European Education Area (EEA) could be used as one such vehicle for promoting and supporting effective STEAM, as it aims at ensuring that all citizens in the EU have the right to high-quality and inclusive education, training and lifelong learning. Supporting EU countries and the European Commission to make the EEA a reality. In this policy development context, particularly interesting would be the promotion of STEAM in the discussions and exchanges currently taking place within the Working Groups[47], in which experts work together to share information about reforms of national education and training systems policies to inspire positive change throughout the EU, contributing to the implementation of EEA actions and reinforcing synergies with other EU policies initiatives. Relevant groups could be those working on schools, including the sub-groups on pathways to school success and learning for sustainability, as well as on higher education and adult learning.

Within the field of higher education, in particular, relevant to creating the desired innovation-friendly climate for STEAM in institutions is the aspect of the European Education Area linked innovation in education[48], which focuses on helping education institutions such as schools and universities to evolve and adapt in order to achieve their core mission of

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[47] https://education.ec.europa.eu/about-eea/working-groups
[48] https://education.ec.europa.eu/education-levels/higher-education/innovation-in-education

educating students to be successful in a complex and interconnected world that faces rapid technological, cultural, economic and demographic change.

The question of school autonomy has been central in the educational discourse for decades. Increased decision-making power has gradually been vested in schools in order to improve democratic participation, the management of public funding for education and, especially in recent years, the quality of teaching. Back in 2009, a Eurydice report provided an outline of the state of school autonomy at primary and lower secondary level.[49] Today, school autonomy remains a key issue on the political agenda of many European countries.

At the international level, OECD very recently (August 2024) published interesting work on flexibility and autonomy[50], two of the core ingredients of creating strong learning environments for STEAM according to Road-STEAMer. Focusing in particular on curriculum flexibility and autonomy in global education systems, this report assesses how curricula adapt to diverse educational needs and contexts, and maps the stakeholders who influence decision-making on curriculum flexibility and discusses dilemmas faced by policymakers and practitioners between curriculum prescription and autonomy. Drawing on international examples, it illustrates how flexible curricula can enhance teaching effectiveness and inclusivity, emphasising key strategies such as enhanced teacher training and collaborative policy making, necessary for flexible curricula to meet educational needs. It also identifies critical factors, such as clear goals, accountability mechanisms, and societal support, which are crucial for successful curriculum implementation.

In line with the above considerations, discussions in the policy gap analysis workshops confirmed both the importance as well as the complexity of securing the appropriate context for effective STEAM education within strong learning environments. Some of the driving questions in them related to practical ways to enable and support transdisciplinarity (e.g. through interprofessional partnerships), or the challenges linked to finding the right space and time for STEAM within real-life school settings. As a participant put it: *"We should be clear about when we want to introduce STEAM and at the expense of what. What shall be omitted in future education?"*. Clearly, such concerns relating to the challenge of implementing effective STEAM education can and should be addressed within the wider evolving discourses about the role, re-organisation, or even re-invention of education in today's and tomorrow's rapidly changing world. An additional potentially interesting resource from the international policy-related context for framing such discussions is OECD's four

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[49] https://www.cedefop.europa.eu/el/news/school-autonomy-europe-policies-and-measures
[50] https://www.oecd.org/en/publications/curriculum-flexibility-and-autonomy_eccbbac2-en.html

scenarios for the future of schooling[51], which consider four alternative education futures for 2040: Schooling extended, Education outsourced, Schools as learning hubs, and Learn-as-you-go (Figure 3).

OECD Scenarios for the Future of Schooling	Goals and functions	Organisation and structures	The teaching workforce	Governance and geopolitics	Challenges for public authorities
Scenario 1 Schooling extended	Schools are key actors in socialisation, qualification, care and credentialing.	Educational monopolies retain all traditional functions of schooling systems.	Teachers in monopolies, with potential new economies of scale and division of tasks.	Strong role for traditional administration and emphasis on international collaboration.	Accommodating diversity and ensuring quality across a common system. Potential trade-off between consensus and innovation.
Scenario 2 Education outsourced	Fragmentation of demand with self-reliant "clients" looking for flexible services.	Diversification of structures: multiple organisational forms available to individuals.	Diversity of roles and status operating within and outside of schools.	Schooling systems as players in a wider (local, national, global) education market.	Supporting access and quality, fixing "market failures". Competing with other providers and ensuring information flows.
Scenario 3 Schools as learning hubs	Flexible schooling arrangements permit greater personalisation and community involvement.	Schools as hubs function to organise multiple configurations of local-global resources.	Professional teachers as nodes of wider networks of flexible expertise.	Strong focus on local decisions. Self-organising units in diverse partnerships.	Diverse interests and power dynamics; potential conflict between local and systemic goals. Large variation in local capacity.
Scenario 4 Learn-as-you-go	Traditional goals and functions of schooling are overwritten by technology.	Dismantling of schooling as a social institution.	Open market of "prosumers" with a central role for communities of practice (local, national, global).	(Global) governance of data and digital technologies becomes key.	Potential for high interventionism (state, corporate) impacts democratic control and individual rights. Risk of high social fragmentation.

Figure 3: Overview of the four OECD scenarios for the future of schooling

Empowering educators

The crucial role of educators for quality education is unquestionable and the emphasis on it is ubiquitous in policy texts.

Particularly relevant to the sub-dimension of empowering educators to develop, sustain and support effective STEAM practices through appropriate training and professional development, is the central focus of the Erasmus+ Programme on supporting "*through lifelong learning, the educational, professional and personal development of people in education, training, youth and sport, in Europe and beyond*", by promoting "*learning mobility of individuals and groups, as well as cooperation, quality, inclusion and equity, excellence, creativity and innovation at the level of organisations and policies*" (cf. the general objective of the Erasmus+ Programme[52]). The recommendation of the Council of the European Union on key competences for lifelong learning also encourages Member States to improve school

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[51] https://www.oecd-ilibrary.org/sites/178ef527-en/1/3/4/index.html?itemId=/content/publication/178ef527-en &_csp_=590c38405df54ad45a1ff6a25ad39f36&itemIGO=oecd&itemContentType=book

[52] https://erasmus-plus.ec.europa.eu/programme-guide/part-a/priorities-of-the-erasmus-programme/objectives-features

education and ensure excellent teaching by further developing initial and continuing vocational education and training[53].

More generally, within the European Education Area, one of the most central focal areas relates to teachers, trainers and school leaders.[54] In this context, it is a stated priority of the European Union to "revalorise the teaching professions and to provide all teachers, trainers and school leaders with high-quality initial education and professional development opportunities", with relevant indicatives including ways to recognise outstanding work by teachers and their schools, establishing European partnerships of teacher education and training providers to develop an international outlook to teacher education, and collaborating with Member States to raise the quality of teaching and learning and to improve support for the profession.

On the international stage, too, OECD develops important work on teachers and educators as "the single most important factor within schools"[55], as well as on education leadership recognising leadership in education as "pivotal for raising school quality and creating environments in which teachers and school staff continuously improve their practice to support student learning and well-being".[56]

Within this broad landscape of recognition of educators' important role and need for training, professional development and support, all efforts to promote policy making for STEAM should point out the conditions and requirements for effective STEAM that Road-STEAM has identified in relation to educators' (including headteachers') appropriate training and professional development.

Bridging gaps between educational sectors

Road-STEAMer's understanding of effective STEAM education recognises an important role to synergies between schools and higher education, as well as between formal education and non-formal and informal learning spaces (e.g. museums, science centres, libraries, community centres, outdoor education centres, after-school programmes, cultural and art workshops, makerspaces and fab labs, hackathons, etc). Our analysis identified some opportunities to promote a STEAM agenda within wider policy contexts developing around

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[53] https://op.europa.eu/en/publication-detail/-/publication/297a33c8-a1f3-11e9-9d01-01aa75ed71a1/language-en
[54] https://education.ec.europa.eu/focus-topics/teachers-trainers-and-school-leaders
[55] https://www.oecd.org/en/topics/teachers-and-educators.html
[56] https://www.oecd.org/en/topics/education-leadership.html

the goal of bridging the gaps existing between educational sectors and spaces. These are briefly presented below.

STEAM and Higher Education: Our analysis revealed that the desired links between STEAM and Higher Education are not always adequately strongly reflected in policy making, while the promotion of the application of STEAM in Higher Education was also a point of considerable discussion in the workshops. However, it should be recognised as a positive step that the current documentation of the European Education Area on "Relevant and high-quality higher education" identifies championing STEAM approaches as one of the ways in which the European Commission is promoting the development of more fit-for-purpose STEM and ICT higher education programmes. Importantly also, the relevant description does not overemphasise a science and technology only focus, but recognises the wider contributions of STEAM: "*STEAM is a set of multidisciplinary approaches to education removing traditional barriers between subjects and disciplines to connect STEM and ICT education with the arts, humanities and social sciences. Doing so fosters knowledge transfer between STEM and non-STEM fields. It also helps to better contextualise STEM subjects in political, environmental, socio-economic and cultural terms.*"[57]

Synergies across the formal-informal learning spectrum: Another idea that featured strongly in our workshop discussions related to not limiting STEAM to schools and universities, but rather extending it to include informal and non-formal educational providers through collaboration with the formal sector. According to workshop participants, this aspect should feature more strongly in the emphasis and content of teacher training and professional development programmes. This is an aspect that should be strengthened in relevant policy making, including in the Erasmus+ actions on the training and professional development of Europe's educators.

More generally, the idea of encouraging synergies between the formal, non-formal and informal education sectors appears to be quite well-established in educational policy making and documentation, including at the European and international levels. For example, back in 2006 UNESCO highlighted good practices of synergy between formal and non-formal education.[58] At the European level, there are several instances where the value of such synergies is recognised. For example, in 2018 the Partnership between the European Commission and the Council of Europe in the field of Youth underlined the value of informal education with special attention to its contribution to citizenship education, civic participation

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[57] https://education.ec.europa.eu/education-levels/higher-education/relevant-and-high-quality-higher-education
[58] https://unesdoc.unesco.org/ark:/48223/pf0000146092

and intercultural dialogue and learning, European citizenship, peace-building and conflict transformation.[59] In the field of science education in particular, the idea of providing increased opportunities for cooperation between various formal and informal learning actors has been widely recognised in Europe for a very long time (cf. the Rocard Report from 2007: "*…opportunities for involving firms, scientists, researchers, engineers, universities, local actors such as cities, associations, parents and other kinds of local resources*"[60]). The emphasis on such synergies is further reinforced in the 2015 Report on science education ("Science education for responsible citizenship"), linking it also to the idea of open schooling, where "*schools, in cooperation with other stakeholders, become an agent of community well-being; families are encouraged to become real partners in school life and activities; professionals from enterprise, civil and wider society are actively involved in bringing real-life projects into the classroom*".[61]

In EU legislation, in this area the emphasis has been predominantly on the validation of non-formal and informal learning, i.e. on establishing systems that allow citizens to identify, document, assess and certify all forms of their learning so that they can demonstrate what they have learned and use this learning in their career and for further education and training (cf. the 2012 Council Recommendation on validation of non-formal and informal learning[62]). The qualitative strengths of synergies between formal, non-formal and informal learning can be further strengthened in European Union legislation, which represents one more opportunity for the promotion of STEAM approaches.

4.3.3 STEAM-relevant policy making and STEAM agenda

We found the "STEAM agenda" dimension as very closely related to several aspects of European educational policy making, therefore presenting important opportunities for anchoring STEAM as an approach towards widely recognised and desired goals.

Addressing societal and industrial needs

Road-STEAMer's emphasis on the contributions of effective STEAM education towards the alignment of educational outcomes with societal as well as with industrial needs, spanning across the spectrum of competencies from life and citizenship to work, employability and the uptake of STEM/STEAM careers.

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[59] https://pjp-eu.coe.int/documents/42128013/47261707/Desk-Study-Value-of-INFED.pdf/05fd448e-6e01-23cf-03ca-010c982cdf8a
[60] https://op.europa.eu/en/publication-detail/-/publication/5e745fa8-d837-4d9d-bdb0-dd13701c1d81
[61] https://op.europa.eu/en/publication-detail/-/publication/a1d14fa0-8dbe-11e5-b8b7-01aa75ed71a1/language-en
[62] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012H1222%2801%29

The documentation of the European Education Area on "Relevant and high-quality higher education" recognises the potential for complementarity of STEAM approaches with the actions outlined in the European Skills Agenda.[63] Stemming from the wider policy area on Employment, Social Affairs and Inclusion, the European Skills Agenda[64] is a five-year plan to help individuals and businesses develop more and better skills and to put them to use, by strengthening sustainable competitiveness, as set out in the European Green Deal; ensuring social fairness, putting into practice the first principle of the European Pillar of Social Rights (access to education, training and lifelong learning for everybody, everywhere in the EU); and building resilience to react to crises, based on the lessons learnt during the COVID-19 pandemic.

In the field of science education, the 2015 "Science Education for Responsible Citizenship" Report highlights the growing importance of science education in an increasingly interconnected and competitive world. As research and technology advance, new opportunities and complex societal challenges emerge, requiring citizens to have a better understanding of science and technology. The report emphasises the need to equip all citizens with the necessary knowledge to engage in science-informed decision-making and innovation. It also provides guidance on increasing the involvement of enterprises and industry in science education, outlining how this can help Europe achieve its goals and develop the skills needed for sustainable and competitive solutions.[65] These focus points clearly and very closely reflect Road-STEAMer's emphasis on the contributions of effective STEAM education towards the alignment of educational outcomes with societal as well as with industrial needs, spanning across the spectrum of competencies from life and citizenship to work, employability and the uptake of STE(A)M careers.

Particularly in relation to the alignment of educational outcomes with industrial needs and the uptake of STE(A)M careers, workshop discussions foregrounded the importance of explaining to policy makers the potential of STEAM and its focus on real-world problems as a way to equip today's learners for jobs and STEAM careers of the future that will require combinations of scientific, technological, creative and artistic skills (e.g. in professions relating digital creativity).

It was also aptly noted by some workshop participants that the alignment of Europe's initiatives in the field of education with industrial needs would require a structured approach

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[63] https://education.ec.europa.eu/education-levels/higher-education/relevant-and-high-quality-higher-education
[64] https://ec.europa.eu/social/main.jsp?catId=1223&langId=en
[65] https://op.europa.eu/en/publication-detail/-/publication/a1d14fa0-8dbe-11e5-b8b7-01aa75ed71a1

with feedback loops between industry evolving needs and priorities of European Union's programmes such as Horizon Europe and Erasmus+. It was felt that an effective STEAM approach would facilitate this in practice, in a bottom-up fashion with the engagement of students, teachers, and all stakeholders.

More generally, in our times of significant change and urgent crises where a highly educated workforce is vital to future innovative solutions, there is a growing emphasis across Europe on investing in education and upskilling, particularly in critical STEM fields like IT and engineering. For example, Ursula Von der Leyen's 2024 agenda for her second term as President of the European Commission includes a "STEM Education Strategic Plan" to address the shortage of qualified STEM teachers and encourage more women to enter these fields.[66] Efforts to promote STEAM should harness the momentum of these greater movements in the education, training and skills landscape, making the several strengths of effective STEAM education clear to policy makers at various levels.

Diversity and equity

A fundamental element of effective STEAM education as defined by Road-STEAMer is equity, which is regarded as an underlying value that should permeate all STEAM practices and transcends all other dimensions of effective STEAM education. Fairness and inclusivity in the design, processes, and outcomes of STEAM education and the support and celebration of diversity are therefore core desired STEAM policy characteristics. The same strong emphasis on equity characterises much of the current educational policy making, which generates additional opportunities for promoting and supporting effective STEAM education within wider policy frameworks and initiatives.

For instance, the first of the listed priorities of the Erasmus+ Programme[67] is related to inclusion and diversity, as it seeks to promote equal opportunities and access, inclusion, diversity and fairness across all its actions, putting mechanisms and resources at the disposal of organisations and participants with fewer opportunities and requiring an inclusive approach for accessibility to a diverse range of participants in the design of all project and activities. What is more, Erasmus+ lists a diverse set of potential barriers hindering participation that need to be addressed (disabilities, health problems, barriers linked to education and training systems, cultural differences, social barriers, economic barriers, barriers linked to discrimination, geographical barriers), pointing out that this list is not

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[66] https://commission.europa.eu/document/download/e6cd4328-673c-4e7a-8683-f63ffb2cf648_en?filename=Political%20Guidelines%202024-2029_EN.pdf
[67] https://erasmus-plus.ec.europa.eu/programme-guide/part-a/priorities-of-the-erasmus-programme

exhaustive and is meant to provide a reference in taking action with a view to increasing accessibility and outreach to people with fewer opportunities.

More widely, in the European Education Area, a focal area is dedicated to integrating equity with improving the quality of education.[68] Citizens' right to high-quality education is regarded as integrally linked to the right to inclusive education as established by the European Pillar of Social Rights[69], since the promotion of a European dimension to teaching fostering common values is *"paramount for creating and maintaining a cohesive European society driving sustainable growth"*. Aspects of equity addressed include the underachievement of students from disadvantaged backgrounds including those living in rural areas, sexism and sexual harassment hampering educational experiences in particular for women and girls, as well as the "*persistent gender gap in fields of study, such as engineering, manufacturing and construction – with only 26% female students – and Information and Communications Technology (ICT) – with just 18% female students (International Computer and Information Literacy Study, 2018)"*. On this background the European Education Area sets the goal "*to tackle inequalities from early years and to decouple social, economic, and cultural status, ethnic and racial background from educational attainment and achievement* ". Within the EEA strategic framework, a working group on equality and values in education and training has been established to contribute to promoting equality and inclusion by encouraging mutual learning and the exchange of information and best practices between Member States, the Commission and stakeholders.

Integrating a focus on STEAM within this broad and inclusive 'wave' of interest in equity and diversity would offer invaluable help to the effort of promoting and supporting effective STEAM education through specific policy initiatives. This would also help shift the focus of the current STEAM-focused policy making on making STEM disciplines more appealing to girls and women, towards fostering better inclusivity not just across the gender spectrum but also to incorporate race, disability and intersectionality (cf. the relevant discussion in section 4.2.2). Of course, this special focus on attracting girls and women into STEM disciplines is not to be abandoned, but rather become part of a broader understanding of how questions of equity and diversity are to be addressed in today's societies. This understanding can be promoted through instilling a discourse on holistic approaches to effective STEAM education within wider policy development frameworks which currently focus merely on attracting girls and women into STEM disciplines (e.g. the recent initiative towards a manifesto for

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gender-inclusive STE(A)M education and careers[70], or the "STEM Education Strategic Plan" within Ursula Von der Leyen's political guidelines for her second term as President of the European Commission in 2024).[71]

Finally, discussion in the policy gap analysis workshops also touched upon several aspects of equity and diversity as desired goals of effective STEAM education, reflecting an agreement with the above-described considerations. Participants brought also into the discussion interesting ideas about specific ways to promote equity and diversity, such as supporting diverse role models even in the hiring policies for teacher recruitment, and communicating the messages of STEAM directly to the communities of marginalised groups by going into their networks and inspiring their participation in STEAM practices.

Overall, our analysis and interaction with experts and practitioners clearly confirmed that efforts to promote and support equity and diversity through effective STEAM education can only benefit from being positioned within the wider evolving discourses and existing policy frameworks aiming to promote these same values in the educational and wider European context.

4.3.4 An example of opportunity for promoting STEAM through relevant policy frameworks: The review of the Digital Education Action Plan

The current review of the EU's Digital Education Action Plan (DEAP) presents a good example of the opportunities that are arising within the wider educational policy context for the promotion of STEAM, offering a chance to fully realise STEAM's transformative potential. Research and initiatives could and should highlight ways in which digital education can benefit from adopting a STEAM approach, such as by utilising the key criteria for effective STEAM practice adopted by the Road-STEAMer project in order to guide future digital education.

While the original Digital Education Action Plan mentions STEAM, it treats the arts as a tool to make STEM more appealing, particularly to women. However, a more ambitious STEAM approach could significantly enhance digital education by emphasising STEAM over STEM, incorporating aspects like interdisciplinary connections integrating scientific, artistic, and technological processes, collaboration, real-world applications, creativity, inclusion and

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[70] https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/towards-manifesto-gender-inclusive-steam-education-and-careers-2022-10-17_en
[71] https://commission.europa.eu/document/download/e6cd4328-673c-4e7a-8683-f63ffb2cf648_en?filename=Political%20Guidelines%202024-2029_EN.pdf

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

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equity. By fostering holistic learning, STEAM can not only improve digital education but also help students tackle big real-world challenges in complex, interdisciplinary, innovative ways. In addition, rather than using STEAM merely as a tool to increase female participation in STEM, the review of DEAP could focus on promoting inclusivity across gender, race, disability, etc.

More details on the review of the Digital Education Action Plan as an opportunity for promoting STEAM can be found in the Second Policy Brief (D7.5[72]) of Road-STEAMer.

4.3.5 Other ideas that emerged at the workshops

During the discussions at the policy gap analysis workshops, several other ideas about ways to promote STEAM through certain policy choices and actions emerged. Among those, it is worth highlighting the concept that the introduction of STEAM as an innovation should be attempted gradually in a cascading approach in which adequate funding and support for an effective STEAM-oriented curriculum reform would first be focused on a small number of pioneering schools and institutions, allowing time to collect more evidence on the impact before introducing the innovation more widely.

More generally, participants pointed out that for the promotion and support of effective STEAM education as defined comprehensively and holistically by Road-STEAMer, there is considerable need for funding from frameworks such as Horizon Europe and Erasmus+, including for in-depth research to provide evidence that will convince policymakers at all levels about the multifaceted positive impact of STEAM.

4.4 Overview of the policy gaps identified

The above discussion of the findings of our policy gap analysis is summarised in Table 5 below. However, this brief tabular presentation can practically only reflect the main broader messages emerging from the analysis; the reader is therefore advised to use this table in conjunction with the full discussion provided in sections 4.1 - 4.3.

Dimension	Desired policy characteristics	Existing policy characteristics	Gap / Comments
Overall	Promotion and support of a holistic approach to STEAM, comprehensively covering the dimensions and sub-dimensions below	Some of the sub-dimensions are covered in existing policy making, albeit only partly or fragmentally	No comprehensive policy making promoting and supporting a holistic approach to STEAM is yet in place

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[72] https://www.road-steamer.eu/wp-content/uploads/2024/08/D7.5-Policy-Brief-Time-for-Bold-Choices.pdf

Dimension	Desired policy characteristics	Existing policy characteristics	Gap / Comments
1. STEAM curriculum	Promotion and support of curriculum for effective STEAM education, focusing on: - including both science literacy and arts literacy - including key aspects such as collaboration, disciplinary inter-relationships, thinking-making-doing, creativity, real-world connection, inclusion-personalization-empowerment	Explicitly STEAM-focused policy making covers some of the sub-dimensions of STEAM curriculum, albeit mostly too narrowly (overemphasising STEAM as an instrument for STEM) Other educational policy making shares important common ground with Road-STEMer's vision of a curriculum for effective STEAM education	No comprehensive policy making promoting and supporting a holistic approach to a curriculum for effective STEAM education is yet in place. There are opportunities to anchor the efforts for the promotion of a curriculum for effective STEAM education within other, wider educational policy frameworks
2. STEAM context	Promotion and support of appropriate learning environments for effective STEAM education, focusing on: - the conditions required for strong learning environments such as autonomy, flexibility, collaboration and innovation-friendliness in organisational climate, culture, structure, leadership - the conditions required in relation to educators' appropriate training and professional development	Explicitly STEAM-focused policy making does not adequately cover this dimension. Other educational policy making shares important common ground with Road-STEMer's vision of creating strong learning environments and appropriately equipping educators for STEAM through training, professional development and support	No comprehensive policy making promoting and supporting appropriate learning environments for effective STEAM education is yet in place. There are opportunities to anchor the efforts for the promotion of appropriate learning environments for effective STEAM education within wider educational policy frameworks
3. STEAM agenda	Promotion and support of the contribution of effective STEAM education towards wider societal goals including: - the alignment of educational outcomes with societal needs through the development of competencies for life and citizenship - the alignment of educational outcomes with industrial needs through the development of competencies for work and employability and the uptake of STEM/STEAM careers - the promotion of diversity and equity, through effective STEAM education relevant and inclusive for all, comprehensively covering gender, ethnic, socio-economic, ability aspects	Explicitly STEAM-focused policy making covers some of the sub-dimensions of agenda, albeit mostly too narrowly (overemphasising STEAM as an instrument for the promotion of STEM-related goals, including attracting girls and women into STEM). Other educational policy making shares important common ground with Road-STEMer's vision of an effective STEAM education actively contributing towards wider societal goals.	No comprehensive policy making promoting and supporting the contribution of effective STEAM education towards wider societal goals is yet in place. There are opportunities to anchor the efforts for the promotion of STEAM's contributions to wider societal goals within other educational policy frameworks.

Table 5: Overview of policy gap analysis for effective STEAM education

5. Conclusions

Our main finding is that comprehensive policy making which would promote and support a holistic approach to STEAM covering the dimensions of our policy gap analysis, is not yet in place. In addition, existing STEAM-focused policy making tends to approach STEAM education too narrowly, overly emphasising STEAM as an instrument for STEM and the promotion of STEM-related goals.

However, our analysis also showed that other existing educational policies seem to share common ground with Road-STEMer's vision for STEAM education. Even if STEAM is not currently within their objectives, such policies are aligned with important aspects of effective STEAM as defined by Road-STEAMer, and are therefore fully conducive to the promotion of good quality STEAM education. As a result, there are considerable opportunities to anchor the efforts for the promotion of a curriculum and appropriate learning environments for effective STEAM education, as well as the efforts for STEAM's contribution to wider societal goals, within these wider educational policy development frameworks.

Therefore, efforts to promote effective STEAM education should both advocate for specific STEAM-focused policies and exploit all available opportunities to use other policy frameworks and contexts as vehicles for STEAM. The message about the potential for positive impact of STEAM approaches on education, and evidence supporting it, should be passed to all agents of educational policy making, from the European, through the national and regional, to the local and institutional level.

In addition, it is important to use funding and support such as through the Horizon Europe and Erasmus+ programmes to promote the translation of European-level frameworks and guidelines for STEAM into national, regional, local and institutional educational policy making with a true, immediate impact on real-life educational contexts, encouraging bottom-up initiatives, all stakeholders' engagement, as well as appropriate training and professional development. Indeed, appropriately prepared and supported educators should be seen as vital catalysts in the process of moving from policies as general high-level frameworks towards the desired STEAM practice in schools, universities and other learning spaces.

What is more, there is space for the development of synergies with other international educational policy making agents such as OECD and UNESCO, albeit always keeping European values and European Union's priorities as the driving force.

Finally, based on the results of the policy gap analysis presented in this report, the Road-STEAMer project will subsequently proceed to formulate policy recommendations to tackle the identified gaps (D3.3, due in February 2025). Then, these recommendations combined with other results and insights from the project will feed into the broader Roadmap for STEAM Education in Europe, the final output of the project, to be released by August 2025.

References

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Road-STEAMer deliverable 2.1: Socio-economic context and relevant needs. https://www.road-steamer.eu/wp-content/uploads/2024/01/D2.1-Socio-economic-context-and-relevant-needs.pdf

Road-STEAMer deliverable 2.2: Conceptual framework for STEAM. https://www.road-steamer.eu/wp-content/uploads/2024/02/RoadSTEAMer-D2.2-Concpetual-Framework.pdf

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Road-STEAMer deliverable 4.2: Mapping of existing STEAM practices. https://www.road-steamer.eu/wp-content/uploads/2024/04/RoadSTEAMer-D4.2-The-landscape-of-STEAM-practices.docx.pdf

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Road-STEAMer deliverable 4.4: Report on lessons learnt. https://www.road-steamer.eu/wp-content/uploads/2024/08/D4.4-Report-on-Lessons-Learnt.pdf

Road-STEAMer deliverable 7.5: Second Policy Brief. https://www.road-steamer.eu/wp-content/uploads/2024/08/D7.5-Policy-Brief-Time-for-Bold-Choices.pdf

Policies and policy-related documents

Note: The policies and policy-related documents referred to in the text of this report are listed in Annex 1.

ANNEX 1: The studied policies and policy-related documents

EU Policy on Educational Issues
https://commission.europa.eu/education/policy-educational-issues_en

European Education Area
https://education.ec.europa.eu/

European Education Area: Teachers, Trainers and School Leaders
https://education.ec.europa.eu/focus-topics/teachers-trainers-and-school-leaders

European Education Area: Improving quality and equity
https://education.ec.europa.eu/focus-topics/improving-quality/about-improving-quality

European Education Area: Relevant and high-quality higher education
https://education.ec.europa.eu/education-levels/higher-education/relevant-and-high-quality-higher-education

European Education Area: Innovation in education
https://education.ec.europa.eu/education-levels/higher-education/innovation-in-education

European Education Area: Working groups of the EEA strategic framework
https://education.ec.europa.eu/about-eea/working-groups

Key competences for lifelong learning
https://op.europa.eu/en/publication-detail/-/publication/297a33c8-a1f3-11e9-9d01-01aa75ed71a1/language-en

Digital Education Action Plan (2021-2027)
https://education.ec.europa.eu/focus-topics/digital-education/action-plan

Communication From the Commission to the European Parliament, the Council, the European Economic and Social Committee and The Committee Of The Regions: Digital Education Action Plan 2021-2027
https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0624

Towards a manifesto for gender-inclusive STE(A)M education and careers
https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/towards-manifesto-gender-inclusive-steam-education-and-careers-2022-10-17_en

Europe's Choice: Political Guidelines for the Next European Commission 2024−2029, Ursula Von Der Leyen, Candidate for European Commission President
https://commission.europa.eu/document/download/e6cd4328-673c-4e7a-8683-f63ffb2cf648_en?filename=Political%20Guidelines%202024-2029_EN.pdf

European Skills Agenda
https://ec.europa.eu/social/main.jsp?catId=1223&langId=en

European Pillar of Social Rights - Building a fairer and more inclusive European Union
https://ec.europa.eu/social/main.jsp?catId=1226&langId=en

Council Recommendation of 20 December 2012 on the validation of non-formal and informal learning
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012H1222%2801%29

Horizon Europe
https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

Horizon Europe work programmes
https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/horizon-europe-work-programmes_en

Horizon Europe: Developing a STE(A)M roadmap for Science Education in Horizon Europe
https://cordis.europa.eu/programme/id/HORIZON_HORIZON-WIDERA-2021-ERA-01-70/en

Horizon Europe: Cultural and creative approaches for gender-responsive STEAM education
https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl2-2023-heritage-01-08

Horizon Europe: Arts and cultural awareness and expression in education and training
https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl2-2024-transformations-01-08

Horizon 2020
https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-2020_en

Erasmus+: Programme
https://erasmus-plus.ec.europa.eu/

Erasmus+ Programme Guide
https://erasmus-plus.ec.europa.eu/programme-guide/erasmus-programme-guide

Erasmus+ Objectives
https://erasmus-plus.ec.europa.eu/programme-guide/part-a/priorities-of-the-erasmus-programme/objectives-features

Erasmus+ Priorities
https://erasmus-plus.ec.europa.eu/programme-guide/part-a/priorities-of-the-erasmus-programme

Science education for responsible citizenship: Report to the European Commission of the expert group on science education
https://op.europa.eu/en/publication-detail/-/publication/a1d14fa0-8dbe-11e5-b8b7-01aa75ed71a1

Science Education NOW: A renewed Pedagogy for the Future of Europe
https://op.europa.eu/en/publication-detail/-/publication/5e745fa8-d837-4d9d-bdb0-dd13701c1d81

JRC Report on Makerspaces for Education and Training
https://publications.jrc.ec.europa.eu/repository/bitstream/JRC117481/makerspaces_2034_education.pdf

Report on arts and cultural education at school in Europe
https://ec.europa.eu/commission/presscorner/detail/en/MEMO_09_448

UNESCO: Culture and Arts Education
https://www.unesco.org/en/articles/what-you-need-know-about-culture-and-arts-education

Cultural Learning Alliance (UK)
https://www.culturallearningalliance.org.uk/

Art & Science across Italy
https://artandscience.infn.it/

School Autonomy in Europe: Policies and Measures
https://www.cedefop.europa.eu/el/news/school-autonomy-europe-policies-and-measures

Synergies between formal and non-formal education: an overview of good practices
https://unesdoc.unesco.org/ark:/48223/pf0000146092

Council of Europe and European Parliament: Desk study on the value of informal education
https://pjp-eu.coe.int/documents/42128013/47261707/Desk-Study-Value-of-INFED.pdf/05fd448e-6e01-23cf-03ca-010c982cdf8a

OECD: Directorate for Education and Skills
https://www.oecd.org/en/about/directorates/directorate-for-education-and-skills.html

OECD: Policy Area of Education and Skills
https://www.oecd.org/en/topics/policy-areas/education-and-skills.html

OECD: Teachers and Educators
https://www.oecd.org/en/topics/teachers-and-educators.html

OECD: Education Leadership
https://www.oecd.org/en/topics/education-leadership.html

OECD: PISA 2022 Creative Thinking assessment
https://www.oecd.org/en/topics/sub-issues/creative-thinking/pisa-2022-creative-thinking.html

OECD Report: Curriculum Flexibility and Autonomy, Promoting a Thriving Learning Environment
https://www.oecd.org/en/publications/curriculum-flexibility-and-autonomy_eccbbac2-en.html

OECD Scenarios for the Future of Schooling
https://www.oecd-ilibrary.org/sites/178ef527-en/1/3/4/index.html?itemId=/content/publication/178ef527-en&_csp_=590c38405df54ad45a1ff6a25ad39f36&itemIGO=oecd&itemContentType=book

ANNEX 2: Materials from the policy gap analysis workshop

A virtual gathering of diverse stakeholders convened on June 27, 2024, for the Policy Gap Analysis Co-Creation Workshop. The main objective of the workshop was to complement our ongoing analysis of relevant policies in Europe, to gather your feedback and listen to your views, as well as those of other practitioners from across Europe with experience in STEAM education and other relevant educational initiatives. We designed a Co-creation workshop for policy gaps that involved collaborative work and discussions, where diverse stakeholders came together to identify and address gaps in existing policies. This workshop leveraged participants' collective knowledge, experience, and perspectives to generate insights that might not emerge in traditional policy-making processes.

During the workshop we discussed the policy gap analysis criteria, briefly and we looked together at the European [Education Area](#), Europe's central policy initiative aimed at helping European Union Member States work together to build more resilient and inclusive education and training systems. We also briefly looked at the recently published results from the [PISA 2022 Creative Thinking assessment](#), OECD's latest measurement of students' capacity to engage productively in the generation, evaluation, and improvement of ideas that can result in original and effective solutions, advances in knowledge, and impactful expressions of imagination. Additionally, we used the policy gap analysis criteria in practice to perform some policy gap analysis on a small sample. Finally, we discussed policy gaps further, based on examples you wished to bring to the table from your own national policy context.
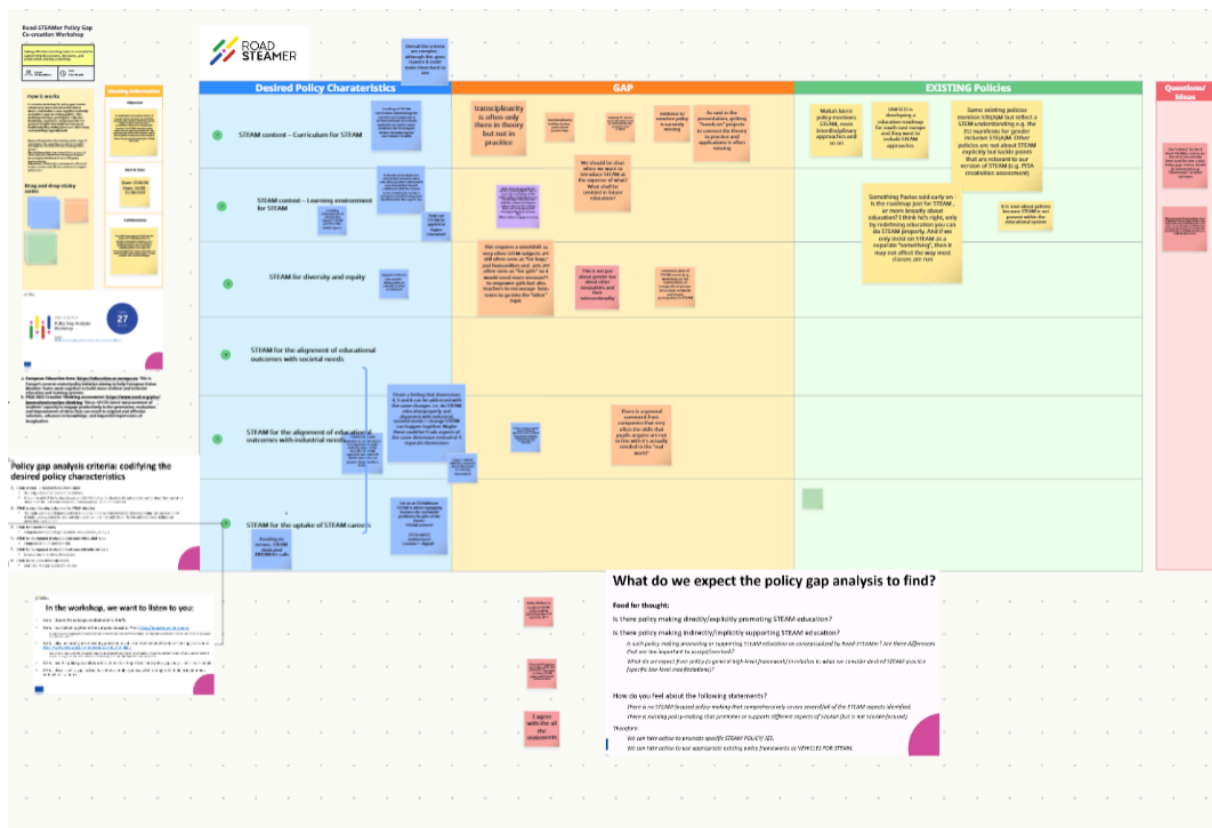
Figure 4: Zoom whiteboard to gather feedback during the policy gap analysis co-creation workshop

The meeting was an important step in fostering collaboration among STEAM education across Europe. Moreover, participants were able to share valuable resources and strengthen their professional networks via LinkedIn. The discussion underscored the importance of future policy making in STEAM education, ensuring that diverse voices are heard and that policy gaps are addressed comprehensively and inclusively.

ANNEX 3: Evolution of the set of policy gap analysis dimensions

A) First draft of policy gap analysis criteria[73] (based on the initial documentary analysis)

1. Increasing science literacy and arts literacy for all - Improving/enhancing/supporting good quality STEAM practice; based on:

    -   *Criteria for analysing STEAM practice (Collaboration, Disciplinary Inter-relationships, Thinking-Making-Doing, Creativity, Real-world Connection, Inclusion/Personalisation/Empowerment)*

    -   *Conditions and requirements for the effective integration of STEAM practices in education (Curriculum frameworks, School structure and organisation, School climate and culture, Teacher training and professional development)*

2. Increasing diversity (gender, ethnic, socio-economic...) and equity

3. Improving alignment between educational outcomes and societal and industrial needs

4. Increasing uptake of STEAM careers.

B) Second draft of policy gap analysis criteria (agreed during the first workshop)

1. Increasing science literacy and arts literacy for all - Improving/enhancing/supporting good quality STEAM practice; based on:

    -   *Criteria for analysing STEAM practice (Collaboration, Disciplinary inter-relationships, Thinking-making-doing, Creativity, Real-world connection, Inclusion/Personalisation/Empowerment)*

    -   *Conditions and requirements for the effective integration of STEAM practices in education (Curriculum frameworks, School structure and organisation, School climate and culture, Teacher and Head Teacher training and professional development)*

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[73] In earlier stages of our work, we used the term "policy gap analysis criteria". Based on feedback from the workshops, we eventually changed this into "policy gap analysis dimensions" to avoid any ambiguity resulting from the already established use of the word "criteria" in Road-STEAMer for the analysis and mapping of STEAM practice.

2. Increasing diversity (gender, ethnic, socio-economic, (dis)ability...) and equity

3. Improving alignment between educational outcomes and societal needs

4. Improving alignment between educational outcomes industrial needs

5. Increasing uptake of STEAM careers

6. Creating and maintaining the school as a strong learning environment (alignment, organisation, school autonomy, school head/teacher training, building resilience and future/AI-proof individuals)

C) Third draft of policy gap analysis dimensions (discussed in the second workshop)

1. STEAM content – Curriculum for STEAM education

    - *Including both science literacy <u>and</u> arts literacy*

    - *Focus on Road-STEAMer's criteria for analysing STEAM practice (Collaboration, Disciplinary Inter-relationships, Thinking-Making-Doing, Creativity, Real-world Connection, Inclusion-Personalization-Empowerment)*

2. STEAM context – Learning environment for STEAM education

    - *Focus on Road-STEAMer's identified conditions and requirements for STEAM: School as a strong learning environment (school autonomy, school structure and organisation, school climate and culture), Teacher and headteacher training and professional development*

3. STEAM for diversity and equity

    - *Comprehensively covering gender, ethnic, socio-economic, ability aspects*

4. STEAM for the alignment of educational outcomes with societal needs

    - *Competencies for life and citizenship*

5. STEAM for the alignment of educational outcomes with industrial needs

    - *Competencies for employability and work*

6. STEAM for the uptake of STE(A)M careers

    - *Making STEM engaging, relevant, inclusive*

D) The policy gap analysis dimensions (finalised after the second workshop)

1. STEAM content[74] – Curriculum for effective STEAM education

   Special focus on:

   - *Including both science literacy <u>and</u> arts literacy*

   - *Aspects corresponding to the criteria for analysing STEAM practice (Collaboration, Disciplinary Inter-relationships, Thinking-Making-Doing, Creativity, Real-world Connection, Inclusion-Personalization-Empowerment)*

2. STEAM context – Learning environments for effective STEAM education

   Special focus on:

   - *Conditions and requirements for STEAM relating to schools (as well as higher education and non-formal/informal learning spaces) as <u>strong learning environments</u> (autonomy, flexibility, collaboration and innovation-friendliness in organisational climate, culture, structure, leadership)*

   - *Conditions and requirements for STEAM relating to educators' (including headteachers') <u>appropriate training and professional development</u>*

3. STEAM agenda – Goals and contributions of effective STEAM education

   Special focus on:

   - *STEAM for the alignment of educational outcomes with <u>societal needs</u> (development of competencies for life and citizenship)*

   - *STEAM for the alignment of educational outcomes with <u>industrial needs</u> (development of competencies for work and employability, uptake of STEM/STEAM careers)*

   - *STEAM for <u>diversity and equity</u> (education relevant and inclusive for all, comprehensively covering gender, ethnic, socio-economic, ability aspects).*

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[74] The term "STEAM content", which was initially chosen to underline the distinction between content vs. context, was eventually replaced by the term "STEAM curriculum" to avoid any misunderstanding that there is special content which is STEAM in and of itself.