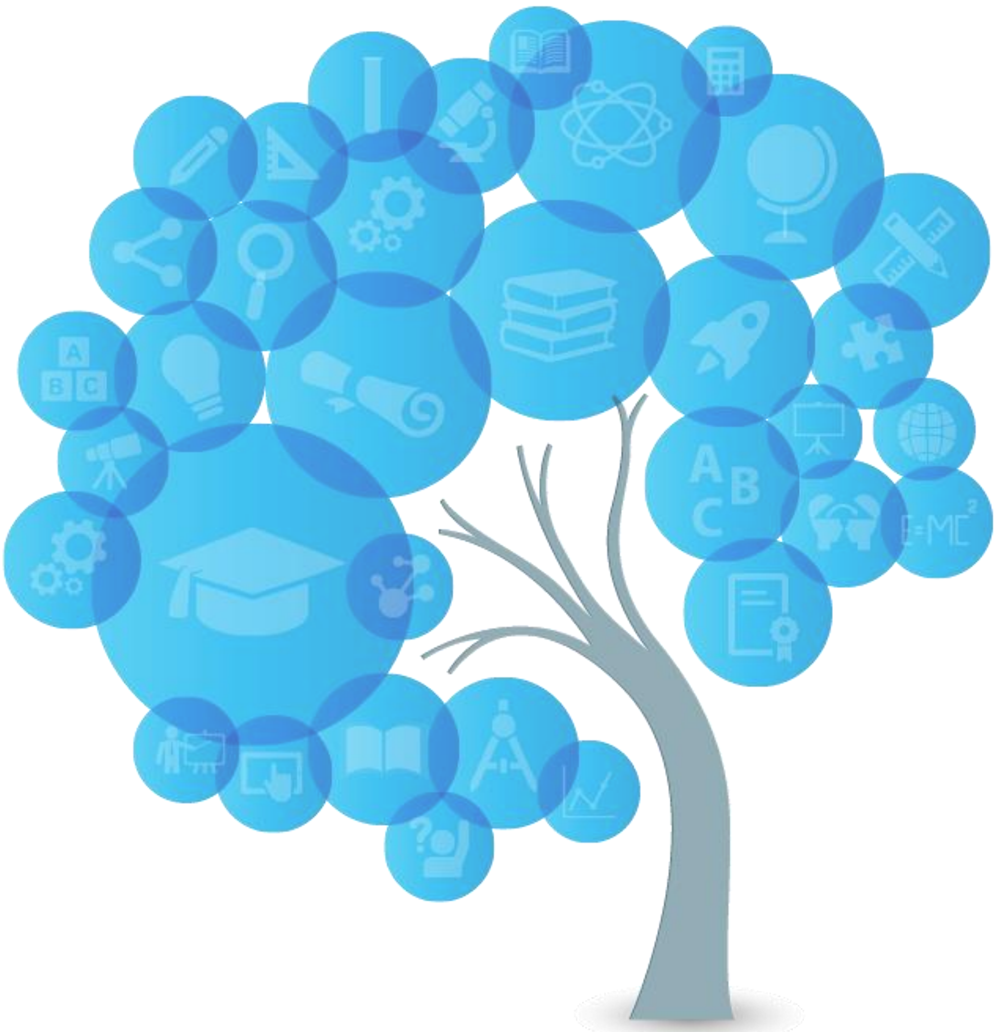

# The STEAM approach to STEM higher education

Policy conclusions from the PLA in
Vienna, 2-3 March 2020

ET2020 Working Group on Higher Education

# SETTING THE SCENE

## PLA setting and participation

This report summarises the conclusions of the Peer Learning Activity (PLA) on "The STEAM approach to STEM Higher Education – Inspiring creative thinking in a digital era, Training the next generation on SDGs[1]". The PLA was hosted by the Austrian Federal Ministry of Higher Education, Science and Research, and took place on 2 and 3 March in Vienna against the backdrop of the Coronavirus outbreak which caused some cancellations.

The PLA brought together representatives of public authorities and higher education institutions (HEIs) from 12 countries/regions[2]. Experts from the European Federation of Education Employers (EFEE), the European Students' Union (ESU) and the national/regional centres promoting STEM[3] also contributed to the meeting, along with the EIT Raw Materials, and the European Consortium of Innovative Universities (ECIU), represented by Dublin City University, as well as STEAM-related Erasmus+ projects.

## Objective and aims

The aim of this PLA was to explore how higher education authorities and institutions can promote the STEAM approach to learning and teaching as a means to increase the attractiveness and relevance of STEM higher education in Europe and to discuss, share and assess the effectiveness of related policies, strategies and practices[4]. It raised awareness of the benefits of the STEAM approach and contributed to the co-creation of a Guiding Framework for developing national STEM priorities and policies (see Annex 1).

Central themes were discussed and good practice was shared on the following topics:

- Policies and strategies for transforming the education sector for STEAM;
- Motivating and inspiring students and improving gender equality through STEAM programme and curricula development;
- Need for more STEM teachers and continuing professional development for STEAM teaching;
- STEAM higher education for Sustainable Development Goals (SDGs).
    - Participants engaged in a mini-challenge "STEAM higher education for SDGs" to identify how higher education institutions can contribute to Europe's Green Deal and United Nations SGDs. The creative and innovative solutions produced will feed into a report on Higher Education for Sustainable Development Goals.

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[1] Sustainable Development Goals: https://sustainabledevelopment.un.org/?menu=1300
[2] AL, AT, BE/FL, ES (Asturias), FI, FR, HR, HU, IT, LT, NMK, RO.
[3] The LUMA Centre Finland, the Dutch Platform Talent voor Technologie, and Valnalon, the government agency for entrepreneurship and innovation in the region of Asturias, Spain.
[4] For STEM/STEAM policies and practices in HE in PLA countries, see Annex 2.

## Context

Europe faces a shortage of STEM and IT professionals. The demand is projected to grow[i]: half of current jobs worldwide will disappear in 25 years, and 90% of the new jobs will require digital skills. The STEM literacy should also improve in order to ensure public trust in scientific data and healthcare experts over disinformation, unfounded conspiracy theories, and anti-scientific movements[ii].

The key reason for the shortage of STEM and IT professionals is the insufficient supply of graduates to meet the demand. Too few young people are taking STEM subjects at higher education. In the EU countries on average 26% of graduates are in STEM fields, however the share varies from 15% to 35% across countries. Dropout rates are high and participation of women is low. The transition to STEM careers is a cause of concern; many STEM graduates find jobs in other fields; for instance, only a third of female graduates in STEM are employed in STEM fields. In some countries, the supply is further reduced by brain drain.

## EU focus

The Commission is promoting a STEAM approach to STEM education to increase the attractiveness and relevance of STEM education. In the Renewed Agenda for Higher Education (2017)[iii], the Commission stressed the need to bring together different education sectors, business and public sector employers to promote the uptake of relevant STE(A)M subjects and modernise STE(A)M and other curricula, including through more multi-disciplinary programmes and cooperation between relevant faculties and higher education institutions.

## Where do we stand?

The PLA confirmed the need for a **stronger focus on STEAM approach to STEM in** higher education policies given the low appeal of STEM studies and careers, gender gaps, labour shortages, high drop-out rates and the need for innovative pedagogical approaches. While STEM aspects are part of the education policies and for strategies in nearly all PLA countries, only a few of them have adopted a STEAM approach to learning and teaching.

The STEAM approach for learning and teaching links STEM and non-STEM fields of study. It promotes transversal skills such as digital competencies, critical thinking, problem-solving, management and entrepreneurial skills as well as cooperation with non-academic partners. It responds to economic, environmental, political and social challenges. STEAM encourages the blending of curiosity and knowledge that is required in the real world. The approach harnesses the potential of other fields to increase the appeal and relevance of STEM education and thereby enables recruitment of more students to STEM.

The PLA showed that there are numerous interpretations of what the A in STEAM stands for. While some countries define A in STEAM as arts and creative fields, for many others, A refers to ALL other disciplines and informal science education. Despite this, the participants agreed that the STEAM approach should be an integrative approach to STEM learning by linking STEM with other disciplines, embedding scientific thinking and an inquiry approach in other fields, and strengthening links and interaction between formal, non-formal and informal science education.

# SUMMARY OF KEY POLICY CONCLUSIONS FROM THE PLA

- STEAM is a transdisciplinary, inclusive, future-oriented approach to learning and teaching. It demonstrates relevance of the individual disciplines, as well as interdisciplinarity and inter-sectoral aspects through inclusion of real-world challenges in learning and teaching. It prepares active and reflective individuals and communities, fostering a mind-set and culture that embraces collaboration and co-design to address societal challenges, sustainability and the needs of the world of work. It develops transversal competences, creativity, and innovation by sharing and combining experience and expertise in a lifelong learning perspective.

- Coordination of STEM/STEAM policies and strategies at national, regional and local levels, alignment across related policy areas and multi-stakeholder backing are necessary to enable effective approaches.

- Evidence-based policies are key enablers to enhance the progress in the STEM uptake, retention and completion and transition to STEM employment: they require investments in data systems to provide micro-grained data, linking the data sources for collective intelligence, and analysing the underlying factors.

- Efforts should be made to ensure gender parity and access and completion in STEM studies for learners from disadvantaged and under-represented groups.

- Investing in teaching staff at schools and higher education institutions is crucial through support for pre-service and in-service teacher training in the STEAM approach. Just as important are reforms in the workload, time allocation and reward systems that foster STEAM learning and teaching.

- Implementing the STEAM approach should focus on innovative student-centred learning and teaching and open ecosystems for learning.

- The STEAM approach should be seen as an integral approach to address Global Sustainable Development Goals and sustainable development in Higher Education programmes where research informs pedagogy and curricula.

- Learning and teaching of STEM through informal and non-formal learning and teaching are key strategies that should be developed alongside the STEAM approach that incorporates interdisciplinary and inter-sectoral aspects.

- Collaboration between higher education institutions and schools and local communities improves the STEM take-up and should start at early school levels and engage all children.

- Evaluation of policies and interventions in higher education should focus on 'what works' in practice, underpinned by the systematic use of evidence to inform policy at national and institutional levels and transparent communication of results.

- European added value may be achieved by Commission supported monitoring, evaluation and best practice sharing of financial and non-financial incentives that support the promotion of the STEAM approach to STEM higher education.

# PLA MESSAGES ON POLICY-MAKING

## 1. Vienna definition of the STEAM approach to STEM education

The PLA participants agreed that one of the main outcomes of the PLA is the formulation of a definition of the STEAM approach. Based on the good practice that was shared at the PLA by participants from national higher education sectors, higher education institutions and the wider non-academic higher education community, the following definition was formulated[5]:

*STEAM is a transdisciplinary, inclusive, future-oriented approach to learning. It prepares active and reflective individuals and communities, fostering a mindset and culture that embraces collaboration and co-design to address societal challenges, sustainability and the needs of the world of work. It develops transversal competences, creativity, and innovation by sharing and combining experience and expertise in a lifelong learning perspective.*

## 2. Multi-stakeholder backed strategies are important in developing effective STEM approaches.

**Coordination and alignment across related policy areas on national, regional and local levels and multi-stakeholder collaboration enable effective approaches to STEM policies.**

Coordination and alignment of policy areas from pre-primary to lifelong learning and employment on national, regional and local levels ensure effective approaches to enhance STEM uptake, completion and transition to STEM employment. While a clearly articulated national framework with coordination and synergies across these policy areas would help attract and retain people in STEM fields, only a few countries have developed such policies to address STEM gaps.

Broad-based collaboration is key to developing commitment to STEM policies. Collaboration between government, higher education institutions and key stakeholders (social partners, local communities, schools) should be embedded in the design and implementation of STEM/STEAM policies to enable the development of multi-stakeholder backed strategies. For instance, the LUMA Centre Finland is a network of 11 universities which is running centres where students, teacher educators and researchers collaborate and interact with education institutions and learners of all ages and the wider community. The concept is based on a multi-stakeholder backed strategy with a steering group of 50 partners and broad collaboration with education authorities, teachers' unions, business and industry, arts and cultural actors etc.

At the European level, the EU STEM Coalition is spearheading development of bottom-up approaches that fit into the context of different national and regional systems. Several PLA countries benefit from the membership in the EU STEM Coalition, as the example of the Asturias4STEAM strategy of the region of Asturias in Spain showed.

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[5] The DG Education, Austria decided to produce a government information note to be submitted by The Austrian Minister of Education, Science and Research to promote the definition in Austria.

### 3. The reasons behind the lack of interest among students to enter STEM fields of study and the shortages of STEM students and graduates vary across countries.

**Evidence-based policies are key enablers to improve uptake, retention and completion in STEM education and transition to STEM employment. They require investments in data systems to provide micro-grained data, linking the data sources from schools to higher education and labour market, and analysing the underlying factors to inform policy.**

The mapping of STEM (or STEAM) landscape at the national/regional level can provide the necessary first step for evidence-based policy and regular monitoring as the example of the region of Asturias showed. This mapping was based on regularly updated data from secondary sources, which included statistics by field of study and occupations, and combining the STEM statistics from all sectors. The annual STEM monitoring in Flanders informs STEM policy and evaluates the progress towards the targets, covering inflow, throughput and outflow of students in STEM courses in secondary and higher education. The departments of employment and education and training collaborate to produce statistics that combine data from secondary and higher education and the labour market.

In most countries, greater efforts are needed to ensure data availability and linking of data to labour market outcomes to identify which specific fields require more attention. ICT was recognised as a common challenge, while in engineering, shortages are evident in some sub-fields.

### 4. Efforts should be made to ensure gender parity and access and completion in STEM studies for learners from disadvantaged and under-represented groups.

**In combatting STEM stereotypes, authorities should ensure that inclusion and gender perspectives are embedded in national and institutional policies. While there is need for policies that promote participation of girls and women in STEM, the policies should also focus on the participation of boys and men in the sciences where women are over-represented.[iv]**

International evidence suggests that to bridge the gaps in STEM for gender, social class and ethnicity, the focus of actions should be on changing the STEM field itself, rather than the people who suffer from the bias. Initiatives to recruit more women to the male-dominated STEM fields often focus on changing the girls so that they would select a STEM field, based on the assumption that STEM is gender neutral. The region of Asturias in Spain has adopted a different approach informed by a study highlighting the variation of STEM uptake and learning outcomes in terms of gender, social class and ethnicity. Consequently, the regional STEAM policy (Asturias4STEAM) aims at reforming educational practices and challenging dominant representations with emphasis on equity, social justice and whole-of-school approaches.

The European Institute for Gender Equality[v] shows how bridging the gender gap in STEM education would help reduce skills gap, increase employment and productivity and reduce occupational segregation. Despite highly productive jobs in STEM, a low proportion of women are studying and graduating in STEM subjects and several countries continue to register gender gaps among STEM graduates with particularly low share of women graduates in ICT and engineering. The PLA country experience showed that the STEAM approach to STEM is helpful in engaging girls in STEM fields, by making

STEM more creative and expressive and increasing its appeal to a broader range of learners.

Entrenched stereotypes and gender bias affect men and women at a young age and are driving girls and women away from pursuing STEM studies and careers, such as start-ups[vi]. Communication strategies at schools and higher education institutions targeting girls and women are important. The role of family support and women role models to encourage girls and women to enter STEM fields of study and occupations must be a part of communication strategies. Programmes that bring together children and their mothers to make science experiments together can help parents to become better prepared to support the STEM orientation of their children.

**National and institutional policies should enable and ensure the inclusion of people from under-represented and disadvantaged groups in STEM studies and STEM-related conversations**. The experience from Ireland shows that the STEAM approach to solving STEM problems helps enhance inclusion of disadvantaged learners in STEM studies and discussions. The Dublin City University's multidisciplinary team is developing an open access Irish Sign Language STEM glossary. This will enhance access to STEM learning and careers of people who are deaf or hard of hearing (DHH), and also ensure that they have access to official information on STEM-related challenges, such as Coronavirus[vii]. Similar projects are ongoing in Denmark, Sweden and the UK.

In Poland, an interdisciplinary project " Joint Architectural Initiative" is conducted by Wroclaw University of Technology, Academy of Physical Education in Wroclaw – Faculty of Physiotherapy in cooperation with Academy of Fine Arts, non-governmental organizations. This initiative breaks the stereotypical way of thinking about the design process. It shows a combination of technical, artistic, medical and social sciences that allows to responsibly shape the urban space. In the last edition, in 2018 for two months, students ( 4 interdisciplinary teams), under the guidance of tutors, designed a barrier-free apartments for specific persons with specific disabilities, as well as a Rehabilitation Center for the "I Can Help" Foundation. The project received a certificate 'Wroclaw without barriers', in the category 'Innovative actions in the field of accessibility'.

## 5. Teacher training should include more emphasis on didactics to demonstrate the economic, societal and environmental relevance of STEM.

**Investing in teaching staff at schools and higher education institutions is crucial through support for pre-service and in-service teacher training, and reforms in the workload, time allocation and reward systems.**

**Attracting students to teaching STEM is crucial due to the European wide shortage of STEM teachers.** According to the 2019 Education and Training Monitor, at least 10 Member States have shortages of STEM teachers[viii]. While PLA countries have increased their efforts to increase STEM students, there appears to be less focus on recruiting students to teaching careers in STEM. Inviting retired teachers back to teaching is a mechanism used in some countries but also requires investments in upskilling.

**Several countries are making efforts to reform education at schools through bringing the STEAM approach to STEM education.** In Flanders, the STEM curricula and didactics have been co-created with schools, researchers, teachers, teacher training colleges etc. and are implemented in secondary education and teachers' pre-service and in-service training. The new STEM Action Plan beginning in 2021 will have a stronger focus on higher education.

**Higher education staff with a teaching role require support to enhance the STEAM approach to STEM and the quality of teaching.** Several institutions are making progress in this area and are open to international collaboration. At Johannes Kepler University, the STEM/STEAM centre of the Linz School of Education enhances creativity and pedagogical innovations in STEM education through research projects and by offering STEM/STEAM education and research methods for Master and PhD Students. In Finland, the LUMA Center develops learner-centred pedagogical innovations in STEM informed by collaborative design-based research with teachers, learners, teacher trainers and teachers in training. The pedagogical innovations are tested in the LUMA labs in universities or schools, and implemented in the classroom and through online courses. Results are published in scientific papers and disseminated in teacher education e.g. through MOOCs.[ix]

**Pre-service and in-service training for Higher Education staff with a teaching role, including doctoral education, should embed innovative pedagogical training, for instance in the form of action-oriented real-life projects.** In many countries, doctoral training, which is the main channel to academia, lacks pedagogical training although junior staff often have a heavy teaching load. National governments could consider regulating the inclusion of innovative pedagogical training in doctoral education in order to address the variation across institutions (and countries), which affects learning outcomes. The quality and the fit-for-purpose of the pre-service and in-service programmes should be evaluated in terms of their ability to support innovative pedagogies including the STEAM approach to STEM education. Consideration should be given whether action-oriented real-life projects could be embedded into programmes, for instance by integrating pre-service and in-service teacher training as well as formal, non-formal and informal learning[x]. Another way is to encourage the development of T-shaped doctoral training to ensure not only the mastery of disciplinary content, but also transversal skills.

**National authorities can support the improvement of pre-service and in-service training of higher education teaching staff through regulation and funding incentives.** They can e.g. require a share of the budget to be dedicated to teachers' in-service training, and increase the number of programmes and initiatives that embed STEAM approaches to STEM education. They can ensure that all HE staff have access to support, space, time and resources to learn, develop and implement new skills and competences, through lifelong learning, mobility and e.g. sabbaticals for pedagogical innovations. Such expectations should be supported with appropriate guidance and adequate resources at the institutional and national level while internal and external quality assurance should promote good practices.

**Reforms in the workload and time allocation systems should be coupled with reward systems, formal acknowledgement of excellence and innovation in teaching, and peer support for scholarship of teaching.** Institutions that wish to make progress in this domain could consider providing a teaching track for appointments, and promotion and tenure to reward innovative teaching. Annual awards at the national and institutional level can be used to recognise excellence in teaching innovation; In Austria, Ars Docendi recognises innovation in higher education teaching and learning in five thematic categories[xi]. Institutions can also enhance collegial support for quality education through support for teachers' academies. For instance, in Helsinki University a 200-strong multidisciplinary community of top teachers provides mentoring in pedagogical development and promotes the scholarship of teaching[xii]. KU Leuven has a platform for teachers which encourages co-creation and co-teaching.

6. **Implementing STEAM approach to STEM should focus on innovative student-centred learning and teaching and open ecosystems for learning.**

**Student-centred learning which engages students as active participants helps prepare students and teachers to meet the new economic, social and global challenges.** The current lack of STEM skills is partly result of learning and teaching which are disconnected from the society and where STEM learning happens in an isolated and disjointed manner without real-world applications. While any approach that leads to more effective learning and meets the needs of students and the society should be encouraged, the STEAM approach can be particularly helpful, given the changes in student expectations and the way they are learning.

**The students' voice should be taken into consideration in learning and teaching in terms of policy design, implementation, and evaluation on national and institutional level.** Teaching approaches in STEM should be aligned with the needs and capabilities of learners, taking into account that students may require bridging courses and student support particularly during the first year of studies. Support for development of guidance and mentoring programmes for students entering STEM fields in higher education, particularly during the first year should be incentivised. Efforts should be made to ensure that institutional policies support the co-creation of learning by students, by relaxing regulations surrounding curricula where needed. Several institutions have reformed, or are in the process of reforming, their curricula or degree structures. For instance the degree reform of the University of Helsinki reduced the number of degree programmes and introduced interdisciplinary master programmes covering also STEAM approach to STEM.

**Governments can encourage HEIs to develop open ecosystems with firms and other partners, involving university-industry collaboration, community engagement and mobility.** France has supported the development of fablabs which are open innovative spaces nurturing the STEAM approach to STEM education and digitalisation and innovative pedagogies that develop transversal competences. A specific model of industry collaboration is championed by the EIT through the learning programmes of the 10 Knowledge Communities (KICs). KICs such as the EIT RawMaterials train "T-shaped" graduates through EIT-labelled master programmes which build disciplinary learning and transdisciplinary skills such as entrepreneurship by connecting academia, industry and research.[xiii]

**The STEAM approach to STEM education takes advantage of interdisciplinary approaches through cross-university collaboration, dedicated transdisciplinary programmes or courses.** Examples include the collaborative joint university programmes which bring together engineering and creative fields of the Polytechnic University Bucharest and the National Theatre and Film University in Romania. Erasmus+ funded project called ArtIST will develop a new interdisciplinary module that will bring together arts, technology, innovation, entrepreneurship and business disciplines. The STEAM approach is also transforming the anatomy teaching in Lyon 1 University by combining art and dance and 3D digital tools developed in collaboration with companies through agile manufacturing[xiv].

7. **STEM has many links with Sustainable Development Goals (SDGs). Related study programmes should contextualise economic, environmental, political and societal relevance and impact to attract more students.**

**Global Sustainable Development Goals and sustainable development can be addressed in Higher Education programmes by combining STEM with non-STEM fields and research informed pedagogy and curricula.**

Providing clean water, green energy and transport systems, improving healthcare, fighting poverty and other equally important challenges require not only STEM knowledge, but learning across disciplines. Challenge-based STEM learning and teaching and transversal skills can be built into the courses. The University of Applied Arts Vienna has developed an interdisciplinary programme bringing together arts, science, philosophy and global challenges to train people who have "a toolset to shape the unknown future"; other universities are embedding the sustainable development goals and global challenges to the existing programmes and courses. In Helsinki University, the research-based pedagogical innovations are aligned with the university's strategic fields in research such as sustainability, digitalization, health and wellbeing. In Poland, two ESF funded projects have been launched  in order to develop and implement the modules of universal design (understood as the design of buildings, products or environments to make them accessible to all people, regardless of age, disability or other factors) in  university curricula  in various areas of study: architecture, transport, digitization, design and visual communication, health service, education.

8. **Enhancing informal and non-formal learning and teaching in STEM is a key strategy that should be developed alongside the STEAM approach that incorporates interdisciplinary and inter-sectoral aspects.**

**Experimentation and experiential learning which provide hands-on learning should supplement theoretical learning.**

Community-based approaches and collaboration between higher education institutions on local and regional level are effective informal and non-formal learning settings that can supplement formal learning. The acquisition of transversal skills in these settings is guaranteed. Ways to recognise and attach credits to these informal and non-formal learning periods requires collaborative effort at European level. In FI, National education authorities support the LUMA Centre Finland to develop a community partnership approach in order to develop "future change makers". Massive Open Online Courses combined with localised learning are widening participation in STEM. In Poland, The Ministry of Science and Higher Education  launched in October 2018 in cooperation with the Young Science Foundation a nationwide MOOC platform : https://navoica.pl/.   The online education ecosystem brings together universities, research institutions, business and non-governmental organizations.

9. **Collaboration between higher education institutions and schools and local communities improves the STEM take-up but should start earlier and engage all children.**

**The links between higher education institutions and learners should start earlier, target all children and be supported by evidence of impact and effectiveness.**

Many higher education institutions pursue school collaboration but this tends to focus on the transition stage to higher education and target high achievers. Country experience shows that university-driven, research-informed programmes can engage learners from 3 years old as well as their families.[xv] Progressive institutions such as KU Leuven are promoting similar approaches.

Early interventions and collaborative partnerships between higher education institutions and schools are key to raising aspirations and improving take-up of STEM studies. Commonly used mechanisms across countries include STEM ambassadors, open days, science clubs, competitions and other in-reach and outreach activities. For instance, the Hungarian STEM Platform promotes programmes which develop the STEM orientation in secondary education through the Children's University and a mobile Mini Tech Fair which reaches out to children all over Hungary and many other ways.

### 10. Evaluation of STEM policies, including the STEAM approach to STEM education should focus on 'what works' in practice.

**The systematic use of evidence to inform policy at national and institutional levels and transparent communication of results is key and should be promoted widely**.
The impact of diverse policies and experimentations in higher education systems and institutions needs to be evaluated in order to ensure improved results. Hungary has used a counterfactual impact evaluation based on data on STEM students, graduates and jobs to evaluate the implementation of ESF-funded HEI programmes which promote entry into higher education and STEM programmes. In Finland, the results of the evaluation of the work of the LUMA Centre Finland network for 2014–2019 are available on the public domain[xvi]. In addition to the evaluation of the entire network, also the annual goals of each LUMA centre are evaluated and cross-evaluated by other centres.

### 11. Support in the form of financial and non-financial incentives helps mobilise autonomous higher education institutions to promote STEAM approach to STEM but calls for careful monitoring and evaluation.

**The promotion of take-up of STEM education can be embedded in university funding through performance-based funding and/or funding agreements, special funds, scholarships and state-funded study places.**

**Launched programmes will require careful monitoring of student progress and transition to the labour market and evaluation of impacts.** In Austria, the Federal Government is funding over 700 new study places in the universities of applied sciences (UAS) in line with the UAS Development and Financing Plan. Furthermore, the Future Initiative for STEM will create 3 000 new training places in VET by 2023, a third of them in UAS in STEM and digitalisation. In France, the National Strategy in Artificial Intelligence for Humanity will double the number of doctoral students in this domain and enhance related research with a funding injection of 665 Million Euro to higher education, research and innovation. In Romania state-funded study places in STEM have ensured a high share of, and a gender balance in STEM enrolments, but dropouts remain high and transition to STEM employment is constrained. Scholarships to students are offered by Croatia and Northern Macedonia.

**Public support can also be channelled to programmes which target pre-tertiary students and which reform learning programmes at schools and higher education institutions**. In Hungary, 23 higher education institutions and their consortia partners have benefited from a total funding of 26 Million Euro to facilitate entry to higher education, and promote STEM programmes in higher education. In Finland, the government is supporting the network of universities and regional centres to enhance the appeal of STEM fields through university funding agreements under national programmes. In Austria, the federal government is allocating 50 Million Euro to 35 projects for digital and social transformation, including STEAM projects through the university performance agreements for 2020-2024.

**A practical step that governments can take to enhance STEM/STEAM at the system, regional and institutional level is to sponsor an agency, centre or network to allow accumulation of knowledge and sustainable and scalable results in STEM**. Examples include the Dutch Platform Talent voor Technologie, and the LUMA Centre Finland.

## FURTHER ACTION AT THE EU LEVEL

**The European Commission contributes to strengthening evidence-based policies in countries and institutions by commissioning comparative research, fostering staff training opportunities, and promoting mobility opportunities and collaboration between higher education institutions.** New research efforts could cover research on the impact of STEAM approach e.g. in equipping students with transversal skills or the long term systematic change in STEM institutions. Research could also develop a shared definition of STEAM as well as a common methodology to assess and compare the state of STEAM/STEM in countries/regions, and to provide an input into a Proposal for a Council Recommendation could enhance the importance of STEAM approach to STEM education. The Commission could also support the development of STEAM didactics and training for teacher educators, as well as a teaching and learning toolbox and set of good practices on how to implement the general principles on programme and course level.

**The open method of coordination enhances peer learning, networking and cooperation between governments and higher education institutions**. Shared learning could help countries and institutions find solutions how to enhance STEAM approach in STEM through exchange of best practice and peer learning activities, with opportunities for participation for teachers and experts from the industry. The open method of coordination could also support networks between national and regional actors to promote the exchange of best practices and 'what works' on the operational level. Workshops and expert missions could assist in developing strategy or policy papers.

**The PLA countries also proposed financial resources in the EU financial perspective for 2021-2027, by making STEAM a priority for funding** under Erasmus+ projects, and introducing an ad hoc Erasmus+ action "STEAM approach to STEM higher education" to encourage interdisciplinarity, and emphasising the interdisciplinary approach in the European Universities Initiative. Several Erasmus Strategic partnerships are already in the pipeline spurred by the PLA, notably partnerships led by the Hungarian Ministry for Innovation and Technology, and Erasmus Mundus proposals led by Lappeenranta University of Technology, Finland. The Flemish Department of Education and Training, the EU STEM Coalition, and the Croatian HE authorities have joined forces to propose a project with focus on a hybrid-teacher concept to address the teacher shortages (Erasmus+ KA3 Call on Policy Experimentation focusing on Dual Teaching/Hybrid Teaching for STEM-Teachers).

## End Notes

[i] CEDEFOP (2016). Skills shortage and surplus occupations in Europe. Cedefop insights into which occupations are in high demand – and why. Briefing Note. https://www.cedefop.europa.eu/files/9115_en.pdf

[ii] Research for CULT Committee – Science and Scientific Literacy as an Educational Challenge, March 2019 & Trust in Science and Changing Landscapes of Communication, January 2019, the European Federation of Academies of Sciences and Humanities.

[iii] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52017DC0247

[iv] This is important also in countries which have higher gender equality but fewer females among STEM graduates due to women being less sensitive to financial returns on education (Gender equality paradox).

[v] According to the European Institute for Gender Equality, closing the gender gap in STEM would contribute to an increase in EU GDP per capita by 2.2 to 3.0% in 2050, while the total EU employment would rise by 850,000 to 1.2 million. See https://eige.europa.eu/gender-mainstreaming/policy-areas/economic-and-financial-affairs/economic-benefits-gender-equality

[vi] In 2018 Unilever Foundry study "Scaling up Diversity," based on survey of 685 founders showed that the majority of the women had experienced unconscious bias at each stage of their start-up's lifecycle and thought that there was a lack of role models.

[vii] Irish Sign Language STEM Glossary, https://www.dcu.ie/islstem/index.shtml

[viii] Education and Training Monitor 2019, Country Specific Reports

[ix] See for example "Towards student-centred solutions and pedagogical innovations in science education through co-design approach within design-based research" https://www.lumat.fi/index.php/lumat/article/view/421

[x] In the LUMA Centre Finland, pre-service and in-service teacher education is typically carried out simultaneously and in collaboration with the industry and teachers at schools. For instance the course 'Math and Science in Society" brings together university teacher education students who collaborate with a company and six schools which each allocate 2 teachers (in math and art) to produce a collaboration model for the school and the industrial company. A dedicated MOOC "How to collaborate with companies?" has been created to support the course.

[xi] http://www.gutelehre.at/fileadmin/user_upload/Heimische_Exzellenz/Ars_Docendi/Ars_Docendi_Kategorien_2020.pdf

[xii] https://www.helsinki.fi/en/university/teachers-academy

[xiii] EIT RawMaterials' EIT –labelled Master programmes: https://eitrawmaterials.eu/eit-rm-academy/labelled-masters/

[xiv] For the 3D tools see https://www.youtube.com/user/Anatomie3DLyon?feature=

[xv] The Luma Centre Finland's JIPPO programme and its virtual science clubs engage 3-to-6-year olds, is research-based and provides training for pre-primary education teachers https://www.luma.fi/sanomat/2015/02/02/jippo-virtuaalikerhosta-tiedeharrastus-koko-perheelle/

[xvi] Aksela, Maija; Lehto, Saara (ed.) (2019) LUMA – yhdessä olemme enemmän!: Intoa matematiikan, luonnontieteiden ja teknologian opetukseen ja opiskeluun. [LUMA – Together we are more! Boost to teaching and studying mathematics, natural sciences and technology. Summary available in English] http://urn.fi/URN:ISBN:978-952-263-663-8

## Annex 1: Guiding Framework for developing national STEM policies and priorities

Examine the correlation between the STEM challenges in the country, underlying priorities and policies of the initiative and robustness of the strategies and actions. (Figure 1)

What is needed to transform the STEM initiative to include the STEAM approach? (Figure 2 and Guiding Questions)

Fig. 1

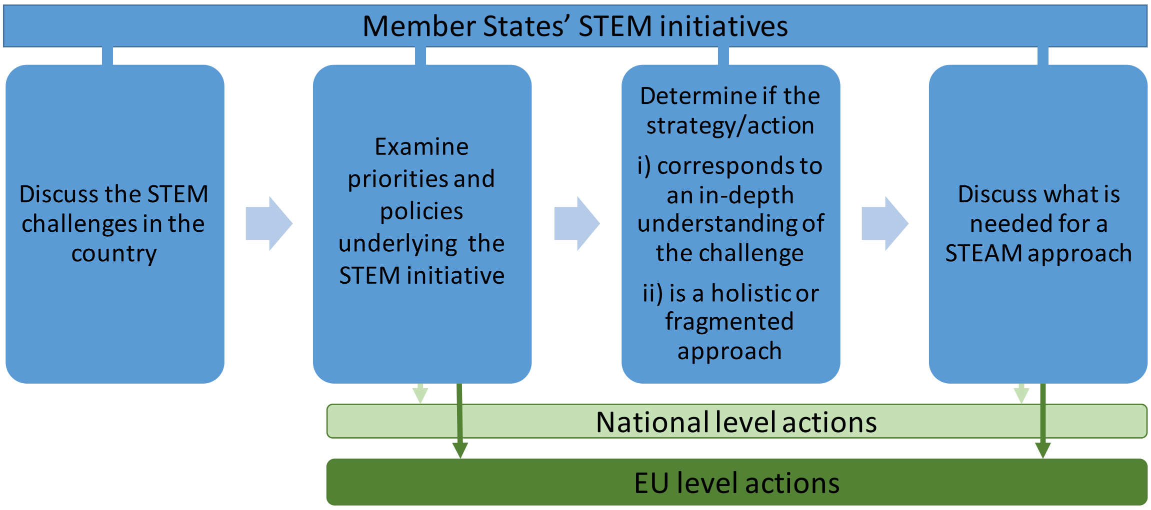
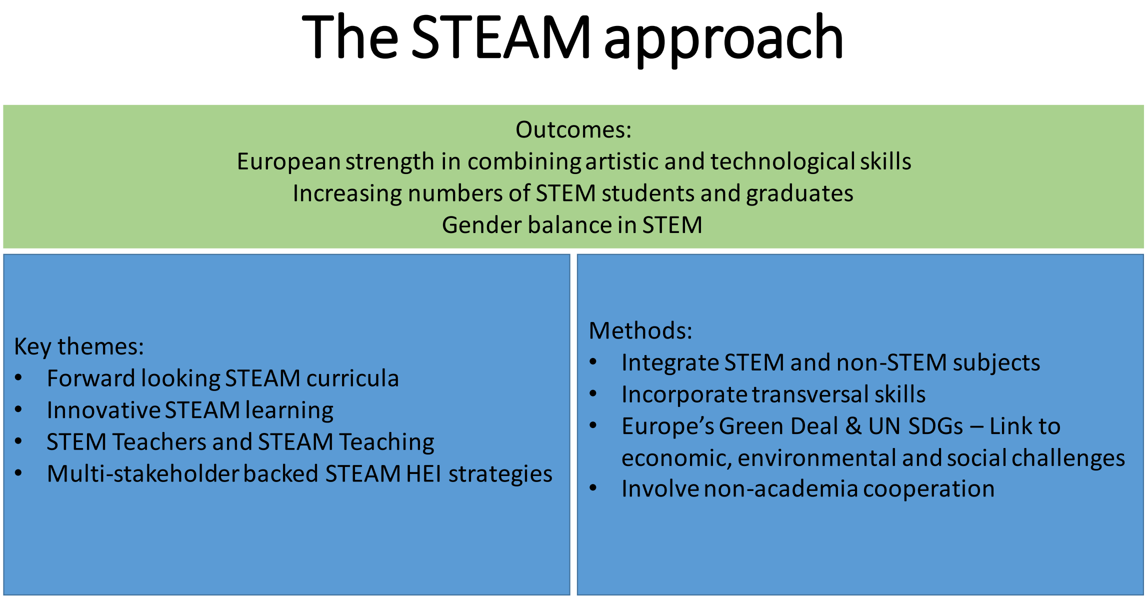



Fig. 2




**Guiding Questions**

- Is there an evidence-based understanding of the challenges in STEM education in your country?
- Are there STEM policies and strategies in place in your country?
- Do the policies and strategies explicitly address shares of STEM students and graduates?
- Is the STEAM approach a known concept at national and higher education institution levels?
- Are there specific policy, funding and regulatory framework conditions (controlled by government and systems regulatory bodies) which help support effective acquisition of (i) STEM, and (ii) STEAM competencies?
- What are the key elements that need to be included to develop STEAM curricula?
- What reforms in current legislation and regulations will be required to bring STEAM into the curricula, formulate new curriculum based on STEAM approach and evaluate such study programmes?
- What are the challenges in involving experts from different fields in curriculum development, learning and teaching and evaluation?
- What extra-curricular activities are needed/effective for the development of STEAM competences?
- Does the STEAM strategy include a focus and actions on participation of women in STEM?
- What elements of the STEAM approach may be leveraged to attract the participation of more women?
- What other policies and strategies outside of higher education are necessary to supplement the focus on women in STEM?

- What are the key elements related to teachers and teaching that need to be included for implementation of effective STEAM strategies?
- What are the main ways to attract, develop and reward teaching staff for STEM/STEAM?
- What kind of strategies and activities are effective in collaborating with public, private and civil society organisations and NGOs in promoting STEM and STEAM competencies in higher education?
- What other aspects would bring added value to the Guiding Framework for STEAM?