State of the art analysis of existing initiatives, best practices and attitudes towards STE(A)M in educational contexts

D2.5 CHOICE Framework for reforming STEM curricula

CHOICE

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Increasing Young People's Motivation to Choose STEM Careers Through an Innovative Cross-Disciplinary STE(A)M Approach to Education

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WP2 - State of the art analysis of existing initiatives,
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Introduction

The need for highly qualified workers in the leading fields of research and innovation, such as STEM (Science, Technology, Engineering and Mathematics), to close the skill gap present in the European labour market has become ever urgent.[1] However, only a minority of young people are motivated to choose a career in STEM: only around 25% of 2016 graduates in EU-28 came from these fields of study, according to EUROSTAT. This is especially true for women, who made up only one third of these graduates in natural sciences, mathematics, statistics, and information and communication technologies in 2016. Weak interest in STEM subjects is often ascribed to a lack of practicality and cross-disciplinary approaches in the teaching of the concerned subjects[2].

There is a recognised need for developing Europe-wide pedagogies and instruments to meet the real needs of learners and teachers in STEM, as well as of higher education institutions and the labour market. Against this background, CHOICE - based on transnational, multi-stakeholder cooperation - aims to contribute to boosting young people's interest in STEM subjects and careers, and to reduce skill mismatches in the labour market. It proposes a practice-oriented, ICT-based educational approach and an innovative STE(A)M-based training path. The project will result in the creation of needs-based and innovative Open Educational Resources (OERs) for STE(A)M education which take into account both a broader context of educational needs and realities as well as individual perceptions and support needs in the classroom. CHOICE has been designed as a cross-disciplinary, bottom-up process, involving key stakeholders in the entire process of designing innovative OERs. Desk research entailed the mapping of local and regional initiatives and of best practices related to STE(A)M, complemented by involvement and consultation of students and teachers, and of representatives from businesses and academia into the whole process, which supports the practice-oriented focus of the OERs and deepens the impact of the action by embedding real-world challenges into the teaching materials.

Background: Framework for reforming STEM curricula

As the strategic link between the recognised needs and matching educational provision, this Framework for reforming STEM curricula (Framework) is to serve as a source of inspiration for STE(A)M pedagogy, outlining the main challenges related to STEM teaching and learning, and potential strategies to cope with them. It is based on the information provided in the CHOICE State-of-the-Art report (SoA report) and the Reflective Practice Case-Study compendium (Compendium), and it is developed on the basis of the identified critical areas in need of improvement within current STEM education in the 4 implementing countries. The robustness of the findings as the basis for the Framework is reflected in the different perspectives captured during the collection of data: primary research covers teachers and learners, higher education

[1] *For example: CEDEFOP – European Centre for the Development of Vocational Training (2016): Skill shortage and surplus occupations in Europe.*

[2] *For example: European Commission (2017) - School development and excellent teaching for a great start in life*

and business representatives and local authorities, in addition to desk research on good practices in STE(A)M education in the four countries.

The Framework has been designed within the scope of **the five macro-areas** (see p.6) which will guide the development of the OERs in CHOICE and as such, forms the basis and inspiration for the OER development during the Design and Development workshops. As a relevant strategic document, the Framework will contain both the identified areas in need of improvement as well as suggestions for **the principle topics to be addressed by the OERs** through cross-disciplinary and creative pedagogical approaches in STE(A)M.

Structure of the document

This document will provide reflections based on the findings of the abovementioned CHOICE mapping activities, with regard to the identified areas of improvement. Although the identified areas of improvement relate to different decision-making/implementation levels (structural - policy makers, system-level access and participation challenges) and individual (teachers, students), the Framework will primarily look at the **individual level** and approaches/methodologies that can support teachers and students towards a STE(A)M pedagogy. It will outline potential approaches and activities towards curricular improvement and an overview of the links between identified problems and potential solutions. Structural barriers and challenges will be addressed in the Policy recommendations (D4.7) developed in a later stage of the CHOICE project.

The guiding questions in the development of this Framework are **WHAT** (areas of improvement), **HOW** (approaches/methodologies) and **WHO** (target group(s) affected by the improvements, i.e. teachers and students), oriented by the findings and with the view to proposing a broader, multi-level and multi-actor scope of ideas for improving STE(A)M curricula. In addition, the framework provides **examples of learning outcomes** linked to the proposed methodologies in terms of skills and competencies for the labour market. The list is not exhaustive.

Identified areas of improvement

CHOICE desk research, survey and reflective groups have revealed a number of areas for improvement vis-à-vis teaching and learning in STEM. Although the Framework focuses on what can be done to support teachers and students towards a STE(A)M curriculum, the reflective groups provide a good background to better understand the obstacles and needed improvement in a wider context, which ultimately affects teaching and learning individuals.

The feedback by the representatives of academia, public and private bodies offer a bigger picture regarding the links with the STE(A)M field and further needs to overcome the persisting gaps and challenges in bringing disassociated disciplines closer. There is general consensus that the STEM pedagogy is highly conducive for the **development of transversal, soft skills** such as critical thinking, problem solving or communication and that fostering these skills should start from **an**

early age, starting from primary school[3]. Their development can be enhanced through a cross-disciplinary STE(A)M approach, and demonstrate how similar skills are developed through linking traditionally unrelated, or even opposed, disciplinary areas, e.g. humanities and STEM (the example of computational thinking in music and informatics). Introducing the STE(A)M approach from an early age is also seen as a great incentive to reduce the existing gender gap in STEM and increase girls' interest and participation in STEM at a later stage of schooling.

From this macro-level perspective, the respondents highlighted three main challenges, i.e. **improvement needs**, which should be addressed towards an effective STE(A)M education. Below is an outline of the three needs and a brief reference as to how CHOICE aims to address them.

1. *A more **integrated, cross-disciplinary curriculum** to encompass more subjects instead of the prevalent silo-based single-subject approaches* – this document (CHOICE Framework on reforming STEM curriculum) aims to address exactly this by collecting examples of needs and linking them with good practices and methodologies that have proven effective in teaching STE(A)M and in the development of desired skills and competences.

2. *A more **innovative, high-quality educational material** to reinforce students' interest in the field* – addressed in CHOICE through 20 innovative Open Education Resources to be co-produced by teachers, students and experts from STEM field on the basis of this Framework.

3. *More **accessible**[4] **professional development and training of teachers** in the STE(A)M approach and use of ICT tools* - CHOICE MOOC will provide teachers with OERs for their STE(A)M teaching practice including guidelines on how to use the MOOC in class and an introductory part on STE(A)M approaches in teaching. Teachers in the four implementation countries will be also trained on STE(A)M approaches and the implementation of the MOOC on STE(A)M education.

Accessibility is a challenge for students as well, especially for girls and for students from disadvantaged backgrounds, which requires more awareness raising, support for teachers to tutor students when needed, more role models in STEM and better access to both information and support.

The findings confirm the need for **a common framework** to assess and evaluate STEM skills at a global level that would enable monitoring and evaluation of learning outcomes. Achieving such an ambitious framework has posed challenges and so far, there has been no consensus on its systematisation among stakeholders and initiatives (see Compendium, p.14). However, it is worth acknowledging some existing initiatives and frameworks that address transversal skills,

[3] *See also: Council conclusions on the role of early childhood education and primary education in fostering creativity, innovation and digital competence (OJ C 172, 27.5.2015, p. 17)*
[4] *For example, issues with teacher training being organised outside of working hours and/or not adequately funded (CHOICE Compendium p. 13)*

such as LifeComp[5], which includes certain transversal skills relevant to STEM within an EU framework (e.g. critical thinking, communication).

The findings from the **survey with teachers and students** are in line with the input by the other stakeholders when it comes to the need to *support and train teachers* in course delivery, and to the need to *develop a more integrated curriculum* to increase STEM attractiveness for students. Although the results somewhat vary across the four countries, these two main issues are shared. Teachers specifically need support in **developing or enhancing digital skills** and, apart from Cyprus, the surveyed teachers in the other three countries do not feel quite confident **teaching in a foreign language**. The need for an **interdisciplinary methodology** in teaching can be seen from two angles: on the one hand, the respondents consider the approach conducive for increasing students' interest in STEM, especially female students and particularly from an early age; on the other hand, it should be taken into account that this implies further support for teachers - to develop the methodology, to deliver with competence and confidence, and finally, to be able to share experiences with other colleagues and engage in peer learning. The majority of the surveyed students (60-70%) find science subjects easier than theoretical ones, which further supports the argument in favour of making STEM classes more tangible and hands-on, in combination with other disciplines, to offer more real-life examples and experiences to students.

CHOICE areas of STE(A)M approach to STEM education

The Framework outlines a number of potential approaches and techniques for improving the STEM pedagogy through a STE(A)M approach, based on the foundation laid so far in the project and on the five macro-areas, within which the OERs will be developed. The collected case studies and examples of good practice will serve as models and inspiration for improvement since they have already shown the benefits of the STE(A)M approach. The ideas put forward will fall under the five macro-areas below, keeping in mind that a clear-cut categorisation might not always be possible given the multidisciplinarity of the approaches.

Macro-area 1: Connecting STEM and art

Connecting STEM and art – using **visual arts** such as drawing, painting, printmaking, sculpturing, ceramics, photography, design or crafts, and **performing arts** including playing music or theatre, performing magic, dance or puppetry while applying artistic creativity and imagination in STEM education.

> **Objectives:** to boost creativity, support development of creative thinking and problem-solving skills by combining STEM subjects with artistic, cultural and creative features. To make STEM subjects more attractive and more easily accessible for wide range of students (including female students and students with disadvantaged background).

[5] *For more information, see: (2020) LifeComp: The European Framework for Personal, Social and Learning to Learn Key Competence*

Focus on skills and competences: STEM skills, creativity, innovation, imagination, out-of-the-box thinking, problem-solving, communication, collaboration, presentation skills, aesthetic skills, manual skills.

Examples of methodologies:

a. **Using origami to teach geometry**. The use of origami in the classroom allows a wide range of mathematics to be covered in an engaging and stimulating way. It was found that while students "[are] excellent at modelling numbers mentally and think logically to solve problems in number, their experience in practical mathematics and consequently the ability to work with geometrical concepts [is] very limited"[6]. Origami represents an effective methodology to teach mathematical concepts while fostering transversal skills such as problem solving (e.g. the fact that there is more than one way to accomplish the same result) and the ability to work co-operatively with others.

b. **Math Science Music**. This initiative, launched by the Herbie Hancock Institute of Jazz, uses music as a tool to teach math and science to young people. The initiative focuses on younger students (primary school, grades 4-6), based on the premise that if students are introduced to STE(A)M subjects at an early age they are more likely to continue on this path in future studies. The website offers a set of free, interactive tools for learning STE(A)M subjects through music, covering topics such as: the concept of proportion, ratio and common multiples through musical rhythms; formal algebra concepts and symbols through jazz history, rhythm and notation; basic sound physics through the concepts of harmony and the use of different musical instruments etc.

c. **Scientific performance.** Introduction of chemical and physical experiments (such as reactions of hydrogen peroxide with potassium iodide, colouring fire, salt crystals experiments) in a performance or an exhibition (for example with a theme of magic) to attract younger students to science and present STEM subject in fun and playful way.

Macro-area 2: Experiential projects

Experiential projects providing hands-on experience in the field of STEM, engaging students in interactive activities and connecting STEM subjects to their application in solving complex real-life challenges and so-called wicked problems.

Objectives: to promote multidisciplinary solutions to complex problems, demonstrate the direct link between STEM subjects and their real-life application, stimulate creative and innovative thinking, collaborative skills and team work and enhancing students' ability to

[6] Pope, S. (Ed.), *The use of origami in the teaching of geometry*, Proceedings of the British Society for Research into Learning Mathematics 22(3) November 2002

search solutions to new problems. Making students understand the connection of STEM to everyday problems with the view of encouraging them to pursue a career in these fields.

Focus on skills and competences: STEM skills, creative thinking, cognitive skills, logic, critical thinking, inquiry skills and problem-solving skills, entrepreneurship, collaboration and communication skills.

Examples of methodologies:

a. **Tinkering[7].** Tinkering is a socio-technical, material and cultural practice; a curious investigative D-I-Y (Do-It-Yourself) approach to invention that is often compared with the practice of hacking, making or modding (modifying). In terms of technological development, tinkering is often discussed as the means through which people attempt to get inside a sealed or closed system and creatively rework it – either for the purpose of simply use, to repair or to make it do something beyond that which was intended by its original designer. Tinkering is seen as a valuable skill for innovation. Being able to tinker or mod reveals an ability to adapt to changing circumstances and unexpected happenings; skills highly regarded in a plethora of commercial and manufacturing contexts.

   Tinkering contributes to the development of STE(A)M competences in a variety of ways, including: learning to formulate hypotheses, verifying them through experimentation and producing theories; learning "how to make things work" through trial and error and a hands-on approach; learning creatively by embracing the seemingly undirected, playful process, which is historically at the base of multiple fundamental discoveries; etc. Moreover, tinkering is a good way to approach and teach sustainability through the recycling already incorporated in its very concept.

b. **Educational robotics.** Educational robotics is an engaging and effective methodology to introduce young learners to programming and computational thinking while leveraging on their creativity. Educational robotics kits are usually coupled with mobile applications which allow learners to apply basic and advanced programming skills with the use of blocks (executable actions represented with icons that can be dragged to reorder them), thus bypassing the need to understand the complex syntax of regular programming languages.

   Creativity comes into play not only in the design of a series of instructions that will make the robot accomplish a certain action, but also in the creation of the robot itself. Educational robotics kits such as LEGO Boost allow young learners to give free rein to their creativity and design innovative solutions to controlled problems presented by the teacher. A complete guide to the use of LEGO Boost in the classroom can be found

[7] Kat Jungnickel, *Tinkering With Technology: Examining past practices and imagined futures*, Australian Council of Learned Academies; Angelika MADER, Edwin DERTIEN, *Tinkering as method in academic teaching*, International Conference On Engineering And Product Design Education (8 & 9 September 2016), Aalborg University, Denmark

[at this link](), together with a set of [four creative scenarios]() where students can apply their problem-solving skills.

c. **Bridging STEM to real-life challenges** – combining some or all of the STEM disciplines together with other disciplines in order to identify connections between the subjects and real-world complex problems and search for a multidisciplinary solution. This includes teaching STEM within an authentic context for the purpose of connecting these subjects to daily problems in order to enhance students' learning experience. Such activities can address some of the challenges listed in the Sustainable Development Goals Agenda and beyond, e.g. Clean Water and Sanitation, Affordable and Clean Energy, Sustainable Cities and Communities, Responsible Consumption and Production, Climate Action, Good Health & Well-Being etc.

Macro-area 3: Stronger focus on language in science and math lessons

Using a stronger focus on language in science and math lessons – adding a linguistic dimension to the STEM education using both mother tongue and/or foreign languages to support development of language skills, but also to engage emotions and imagination for example through literature, poems or riddles.

Objectives: to enhance students' communication skills in mother tongue, support learning of foreign language and encourage students to use scientific literature and other resources in English. Facilitate inclusion of students coming from families with migratory background or ethnic groups who can struggle with communication barrier. Increase focus on discussion and discourse in STEM teaching to develop self-confidence by knowing to express oneself in a content area.

Focus on skills and competences: STEM skills, computational thinking, communication skills, presentation skills, language skills including work with written text as well as spoken language, vocabulary, discourse, explanation and argumentation in mother tongue and in a foreign language.

Examples of methodologies:

d. **Content and language integrated learning ([CLIL]())** - is an approach for learning content through an additional language (foreign or second), thus teaching both the subject and the language. It means using language as the medium of instruction rather than as the final goal. The language immersion method was used extensively in adult learning but can be adapted to the education of the youth as this approach produces a more immediate results and it appeals to self-motivated learners who possess a basic knowledge and understanding of the target language.

e. **Computational thinking training -** is a set of processes required in understanding problems by approaching them in a systematic manner, and formulating solutions. It involves logic, assessment, patterns, automation, and generalisation. Computational thinking does not only involve computers, but also examples of how music and grammar are involved with computational thinking. (Example: The School of Computational Thought, Greece, p.26 SoA report)

Macro-area 4: Technology in social sciences

Using technology in social sciences – using digital technologies, tools and application as well as multimedia in social research, history research, analysis of data to explain social phenomena, economic development etc.

Objectives: to support development of students' digital skills, digital literacy and use of digital technologies in learning social sciences, doing research and analysing data as well as digital collaboration. To support the use of multimedia in presentation of various topics, data and research results and to promote inquiry-based learning.

Focus on skills and competences: STEM skills, analytical skills, critical thinking, computational skills, mathematic and statistical skills in digital environment, such as use of spreadsheet and analytical tools, digital and data literacy, ability to use digital tools and multimedia for presentation, exchange and collaboration, critical thinking, inquiry skills.

Examples of methodologies:

f. **Collaborative digital storytelling** – is an approach that fosters inquiry-based learning, teamwork and creativity by creating personal narratives created through a participatory multimedia process. Pupils research on a specific topic, for example climate change and refugees, and share opinions so they learn to use their own voice, learn digital skills and programming through a given software and create a collaborative project on what they have researched. It is an example of how to connect with children, connected education and education with values and also of how they can develop a lot of digital skills in a transversal way. (p.13 Compendium)

g. **Combining history and science in teaching** – is an approach of teaching scientific methods through research on historical topics or teaching history of science. This approach combines the elements of science and the cultural context in which scientific methods or discoveries took place by engaging students in problem-solving activities and guiding them through the process and methods of scientific research.

h. **Orientation in Big Data** - exploring interesting and current topics including social, demographic and economic phenomena using digital technologies and tools to access digital data resources, evaluate and analyse them. In current context, students can observe the pandemic dynamics through a simulation of diseases spreading by linking data science and analytical skills in the context of societal and health challenges, especially pertinent in the current context of COVID-19.

Macro-area 5: Sports in STEM education

Turning sports classes into learning experiences– connecting STEM education initiatives with sports and physical activity is an effective, hands-on and fun approach to teaching STEM and promoting heathy lifestyle. This can include a wide range of outdoor activities based on exploration of the environment, adventure-based activities and experiments in nature.

Objectives: to make STEM teaching more tangible and exciting through hands-on, sports-themed lessons spanning biomechanics, physics, geometry, mathematics, biology and nutrition science. Increasing attractivity of STEM for a wider range of students by integrating their favourite sports in STEM lessons in a theoretical as well as a practical way. To promote physical activity and healthy lifestyle among students.

Focus on skills and competences: STEM skills, analytical skills, critical and thinking, collaboration, problem-solving skills, decision-making skills, physical literacy and movement skills.

Examples of methodologies:

i. **Bounce, it's about energy** – using a bouncing basketball ball to explore kinetic, potential and thermic energy and their transformation during a basketball game. Observing how the ball bounces and drops and how the energies transform in the process and thus learning the law of conservation of energy. Geometry can be taught as well, especially the parabolic arc of a ball swishing through the net.
j. **Physical fitness test** – exploring and evaluating physical condition by using real data collected during a sports lesson or a physical activity and applying them to the Gallagher and Brouha Test to calculate the fitness index and determine appropriate grades. Students can also calculate calories intake and output and discuss the impact of physical activity to human health. In this way, analytical and mathematical thinking can be taught together with biology and nutrition science while promoting physical activity and its connecting to health and well-being.
k. **Outdoor activities** can be incorporated in any of the subjects, using the environment to explore natural phenomena and make connections with the real world, for example in Ecobiology classes, Chemistry lessons on topics linked to environmental issues, or teaching coding through football matches.

Overview table

The table below was developed as a basic but comprehensive source of reference for the development of the OERs in the next stage of the CHOICE project. Linking to the five macro-areas, the table provides suggestions for STE(A)M approaches, methodologies and activities that can support the development of the needed competences of students and teachers, as identified in the project. It also provides links and references to some practices that have proven effective in applying STE(A)M pedagogy.

Needs identified	Desired competences	Learning objectives	Possible approaches / methodologies, examples of possible activities	Related Macro-area(s)	Examples of good practice from CHOICE
TEACHERS					
Support in ICT use	Digital skills and competences	Be able to use digital technologies, means and tools in STEM/STE(A)M T&L	Use of different IT tools in teaching; Coding, graphic design training etc.	All, especially 4	Courses for teachers on how to teach ICT Google Coding Education Tool
Teaching STEM in a foreign language	Linguistic skills, presentation and argumentation skills	Become able to use foreign languages as a teaching tool, understanding, oral and written reproduction	CLIL teacher training, teaching in a foreign language, dual language lessons, translation of texts related to STEM;	All, especially 3	Example: A project by High School Benedetto Croce (Italy) offers 6h of Maths lessons in English, combined with lab time and use of technologies such as 3D print, sensors, etc. through a DIY approach (p.13 SoA report)
Exchange among teachers (peer exchange)	Communication, collaboration, co-creation	Be able to share knowledge and experience with peers in order to develop and apply innovative teaching methodologies	Round-table discussion, focus group, co-creation; co-production of education resources	All	CHOICE D&D workshops
STUDENTS					
Motivation of students/interest in STEM	STEM skills, awareness of academic and	Enhanced interest in STEM, degree/careers,	Exhibitions, competitions, use of high-quality and state-of-the-art equipment; using	All	The European Space Agency – resources for schools

	career paths in STEM field	understanding of the link between STEM and daily life/real-world challenges	students' favourite sport to teach STEM, ESA resources (multi-disciplinary)		
Computational skills	Computational skills include problem-solving skills and other mental skills such as abstraction, analysis and automation for designing computations (code writing, programming, system set-ups),	Ability to approach a problem in a systematic manner, create and formulate a solution, developed advanced problem-solving skills, ability to get computers to do jobs for people.	Different creative activities, use of arts/humanities to teach science, use of ICT in STEM and non-STEM education; Origami, making links between grammar, maths, music; computer programming activities, such as Scratch, coding, programming, robotics.	All, especially 3, 4	The School of Computational Thought, Greece, p.26 SoA report) Art, Origami and Mathematics Inventors4Change using Scratch programming tool
Soft/transversal skills[8]	Capacity for innovation	Be able to think out of the box, come up with new ideas and solutions applying multidisciplinary approach	Using arts in STEM teaching, experimental projects, Tinkering, coding, robotics, bridging STEM to real-life	All	Example: Archimedes Prize (Italy) - national competition for designing new board games (p.15 SoA report)
	Critical thinking	Assess information and argue to support reasoned conclusions and develop innovative solutions	Research or project-based tasks, orientation in Big Data, computational thinking, bridging STEM to real-world challenges,	All, especially 2, 4, 5	Linking history and science (through e.g. doing research on the history of science). Example: Liceo

[8] For further reference see *LifeComp: The European Framework for Personal, Social and Learning to Learn Key Competence* and 2018 Council Recommendation on key competences for lifelong learning https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)&from=EN

			Combining history and science in teaching		Matematico project (Italy), which explores relationships between mathematics and literature, history, philosophy, as well as with chemistry and biology, re-launching the role that mathematics has played over the centuries in the social context (p.14 SoA report)
	Creativity	Think strategically use of imagination, be able to generate original ideas to solve problems	Engagement of creative industries; Using visual and other arts Robotics use of high-quality and state-of-the-art equipment	All	See the examples of methodologies on p.4-8 of this Framework
	Problem-solving skills	Develop a mix of skills and competences such as creativity, analytical skills, the ability to handle obstacles and change, and an attitude of openness to apply prior learning and life experiences and the	Inquiry-based learning	All	(See the examples of methodologies on p.4-8 of this Framework) Bridging STEM to real-life challenges Computational thinking training

		curiosity to look for opportunities to learn and develop in a variety of life contexts			
	Communication & presentation skills	Become aware of the need for a variety of communication strategies, language registers, and tools that are adapted to context and content; Understanding and managing interactions and conversations in different socio-cultural contexts and domain-specific situations; Listening to others and engaging in conversations with confidence, assertiveness, clarity and reciprocity, both in personal and social contexts	Use of language to teach other subjects CLIL Inquiry-based learning, projects, investigations, (collaborative) Digital storytelling,	All, especially 1, 2, 3	**CLIL** definition (BC website) Digital storytelling: Compendium, p.13: Inventors4Change
	Entrepreneurship	Build capacity to act upon opportunities and ideas, and to	Connecting STEM to real-life challenges, project-based learning	All, especially 2	Example: Youth Makerspace Larnaca (Cyprus) which forms

		transform them into values for others			hubs for hands-on, project-based learning, creation and invention supporting the integration of Art in STEM subjects (p.22 SoA report)
	Analytical skills		Simulations, Big Data analysis	All, especially 4	(p.8 of this Framework) [Orientation in Big Data](#)
	Collaboration, teamwork	Engage in group activity and teamwork acknowledging and respecting others, fair share of tasks, resources and responsibility, coping with conflicts and negotiating disagreements	Collaborative digital storytelling,	All	Example: National competition (Cyprus) for team-based research projects focusing on social sciences, applied sciences, economics or health (p.23 SoA report)
Digital competences	Basic digital skills: using devices, handling information, creating and editing, communicating, transacting, being safe and	Be able to use digital technologies, tools and resources in learning STEM and non-STEM subjects. Be able to use digital means for research, presentation, communication.	Use of electronics and digital technologies in education practice with the focus of active use by students; Geogebra Digital storytelling Orientation in Big Data	4	Geogebra Online App - - online tool on teaching and learning mathematics (algebra and geometric). Digital storytelling: Compendium, p.13: Inventors4Change /

	responsible online. Advanced digital skill such as coding, programming, data science and data analytics, using and development of multimedia				
“Green” competence	Awareness and ability to act in line with the “green” principles of sustainability and environmental protection	Have the knowledge, abilities, values and attitudes needed to live in, develop and support a sustainable and resource-efficient society[9]	Combining subject-specific teaching with activities based on exploration, experimentation and observation of the environment, especially outdoors.	All, especiall y 2 and 5	Tinkering (recycling), combining sports and coding, ecobiology (see p.11 of this Framework)

[9] European Centre for the Development of Vocational Training (Cedefop): http://www.cedefop.europa.eu

Conclusions

This Framework for reforming STEM curricula aims to address the identified need of increasing the attractiveness of STEM subjects and careers, by proposing hands-on, multidisciplinary approaches and activities in teaching and learning STEM, and with the view to reducing skill mismatches in the labour market.

The Framework is based on the previous work within the CHOICE project, which was collected into two main documents: the State-of-the-Art report containing 1) examples of good practices in STE(A)M pedagogy from Italy, Greece, Cyprus and Spain, and 2) results from the surveys conducted with students and teachers in the four countries, which look into their attitudes vis-à-vis teaching and learning in STEM; and the Reflective Practice Case-Study compendium comprising examples of good practice and findings from the reflective groups with academia, businesses and public officials.

As already seen in the previous sections of this Framework, the (Europe-wide) need for teacher support and professional development in the STEM field is clear, as much as the need to diversify STEM curricula and link them better to other disciplines (e.g. humanities, social sciences, arts, sport). The Framework contains collected examples of STE(A)M pedagogy with demonstrated effectiveness in teaching and learning, especially in the five macro-areas within which the CHOICE OERs will be developed in the next step of the project.

This document will serve as the basis for the development of 20 innovative Open Education Resources to be co-produced by teachers, students and experts from STEM field. Finally, the project will offer a MOOC training programme based on OERs to enable teachers and educators in different European teaching environments to smoothen the implementation of OERs into their teaching activities, help strengthen their ICT skills as well as provide access to a new and innovative approach on STE(A)M education.

CONSORTIUM

Coordinator
CESIE
Italy
info@cesie.org

Liceo Scientifico "Benedetto Croce"
Italy
PAPS100008@istruzione.it

GrantXpert Consulting Ltd
Cyprus
admin@grantxpert.eu

Grammar school Nicosia
Cyprus
info@grammarschool.ac.cy

EUROTraining
Greece
info@eurotraining.gr

Regional Directorate of Education of Western Greece
Greece
pdede@sch.gr

Blue Room innovation
Spain
info@blueroominnovation.com

Institut de Maçanet de la Selva
Spain
b7008951@xtec.cat

Lifelong Learning Platform
Belgium
projects@lllplatform.eu

euchoice.eu

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