CHOICE - INCREASING YOUNG PEOPLE'S MOTIVATION TO CHOOSE STEM CAREERS THROUGH AN INNOVATIVE CROSS-DISCIPLINARY STE(A)M APPROACH TO EDUCATION

NATIONAL REPORTS ON LOCAL AND REGIONAL INITIATIVES, BEST PRACTICES, STUDENTS' ATTITUDES AND TEACHERS' APPROACHES TO STE(A)M EDUCATION IN ITALY

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1 Introduction

The first step of WP2 consists in conducting desk research as well as the collection of data to lay the basis for the innovative creation of cross-disciplinary OERs for the MOOC on STE(A)M education. Furthermore, the project partners gathered information on the attitudes of students towards STEM subjects and careers and the current teaching of STEM subjects as well as the teachers' and school directors' practical approaches to conducting the concerned subjects. The last step in the information collection process will be national reflective groups with business and HEI representatives as well as local authorities in order to understand the existing issues regarding the current STEM curricula creating gaps between needs of the academic / work sector and the skills graduates are equipped with.

The information collected by CESIE are summarized in the following national report.

The aim of the report is to stress the importance of current changes in the education field, regarding the increasing importance of integrating STE(A)M approaches in schools' curricula. The report is focused on Italy: after a brief introduction on the Italian education system and how it is organised, the report will stress the national policies and national plans and programmes implemented by the Ministry of Education and Research (MIUR) in order to foster the teaching of regarding STEM disciplines, particularly in high schools.

Moreover, an important list of good practices can be found in paragraph 2 "Integration of STE(A)M in schools": the good practices concern the integration of STE(A)M in schools. National level as well as local level initiatives have been reported, as the initiatives implemented by the high school Benedetto Croce which is the Italian school partner in the CHOICE project.

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AS example of good practices at international level, the report will mention three different European projects in which CESIE is involved, aiming at fostering STE(A)M approach and reducing the gender gap in such disciplines.

This report gives an overview of the current state in Italy concerning STEM education, the already existing initiatives on reforming STEM education and applying STE(A)M approaches, and the current stand on STEM education and careers according to students and teachers.

This national report will lay the basis for the comprehensive State of the Art study, which will summarise, compare and discuss all nationally collected results.

1 Background information

1.1 Information about Italy

Italy, country of south-central Europe, is a peninsula of the Mediterranean Sea. At its broad top stand the Alps, which separate Italy from France, Switzerland, Austria and Slovenia.

The total area of the Country is 301,340 km^2 with an estimate population of 60,317,546 inhabitants. The capital and largest city is Rome. Italy is subdivided into 20 regions, five of them having a special autonomous status that enables them to enact legislation on some of their local matters. The Country is further divided into 14 metropolitan cities and 96 provinces.

The official language is Italian and there are an estimated 64 million native Italian speakers, even if there are different dialects with market differences among regions. Because of recent immigration history, Italy has sizeable populations whose native language is not Italian: according to the Italian National Institute of Statistics, Romanian is the most common mother tongue among foreign residents in Italy: almost 800,000 people speak Romanian as their first language. Other prevalent mother tongues are Arabic, Albanian and Spanish.

Regarding the education system in Italy, the Ministry **of Education, University and Research (MIUR)** is responsible for general administration at national level. The Ministry of Education has decentralised offices (Regional School Offices - USRs) that guarantee the application of general

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provisions and the respect of the minimum performance requirements and of standards in each Region. The education system is organised as follow:

- **Pre-primary school** for children between 3 and 6 years of age
- First cycle of education lasting 8 years, made up of: **primary education**, lasting 5 years, for children between 6 and 11 years of age; **lower secondary school**, lasting 3 years, for children between 11 and 14 years of age
- Second cycle of education offering two different pathways: **high schools or vocational training schools**, from 14 to 19 years old
- **Higher education** offered by Universities, polytechnics included, Higher Education Institutions in Art and Music system ("AFAM")

With a specific focus on the second cycle of education, it lasts five years and is delivered by six types of high schools specialising in the following areas: art (*Liceo artistico*), classical studies (*Liceo classico*), science (*Liceo scientifico*), languages (*Liceo linguistico*), music and dance (*Liceo musicale*), human sciences (*Liceo delle scienze umane*). The science based high school offers an option in applied sciences. At the end of secondary school, students take a State examination to verify the knowledge and skills gained during the last year of the study path, according to the general and specific objectives of each branch of study, as well as the general cultural knowledge and the critical skills of the candidates.[1]

Students' curricula are different depending on the high school they choose; nonetheless, in recent years, the importance of choosing a STEM career has grown more and more: a report from the McKinsey Global Institute, for example, states that in less than ten years the demand for STEM jobs will triple compared to traditional jobs.[2]

The acronym STEM derives from **Science, Technology, Engineering & Mathematics**, it is a curriculum based on the idea of educating students in four specific disciplines — science, technology, engineering and mathematics — in an interdisciplinary and applied approach. Rather than teach the four disciplines as separate and discrete subjects, STEM integrates them

[1] Key features of the education system, Italy
[2] *Jobs lost, jobs gained: What the future of work will mean for jobs, skills, and wages,* McKinsey Global Institute, 2017

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into a cohesive learning paradigm based on real-world applications.. On the other hand, the acronym STE(A)M stress the importance of including Arts in teaching STEM disciplines, as a new and innovative teaching method. It also means "All" including both STEM and no-STEM subjects. STE(A)M is a way to take the benefits of STEM and complete the package by integrating these principles in and through the arts. STEAM takes STEM to the next level: it allows students to connect their learning in these critical areas together with arts practices, elements, design principles, and standards to provide the whole pallet of learning at their disposal. STEAM removes limitations and replaces them with wonder, critique, inquiry, and innovation.

The impact of STEM skills on advanced economies is increasingly relevant, but Italy is one of the latter among the OECD countries both for **digital skills of the population** (Digital Agenda Scoreboard) and for **STEM degrees** (25% in Italy compared to Germany at 37%).

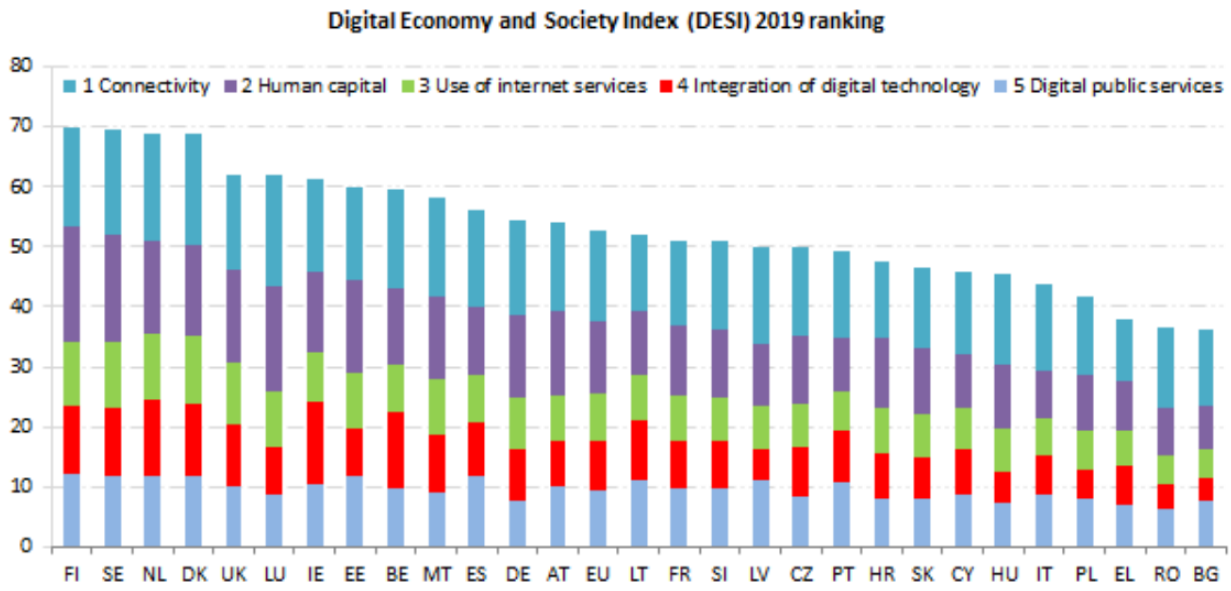

Figure 1: The Digital Economy and Society Index (DESI), 2019.[3]

[3] The Digital Economy and Society Index (DESI) is a composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU member states in digital competitiveness.

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In the index above, Italy rank the lowest overall on DESI's Human Capital dimension, as internet user skills and advanced skills. The main reason of this data is that a high percentage of people did not use the internet or only seldom did so. Italy's slow performance is mainly driven by the usage side: low levels of digital skills translate in low levels of a range of indicators: the uptake of broadband, the number of internet users, the engagement in a variety of internet activities (including e-Government), the use of e-Commerce and the number of digital curricula (i.e. STEM degrees and ICT specialists).[4]

On its part, the Italian government set up in 2015 the national **Coalition for Digital Competences**[5] (*Coalizione per le Competenze Digitali*) which has coordinated 127 projects to develop digital competences for citizens, entrepreneurs, job holders and civil servants (worth of mention, the project *'Crescere in digitale'*[6] and *'Eccellenze in digitale'*[7]).

Moreover, the Italian government tend to generalise a digital culture for all through national programmes focused on ICT: the main purpose is to help people to evolve in increasingly connected and digital societies. To this end, in 2015, **the Italian Ministry of Education** launched the **National Plan for Digital Education** (*Piano Nazionale Scuola Digitale).* This plan has several aims:

- to provide schools with tools and conditions that allow full access to the information society;
- to develop students' knowledge and skills in the digital field, in order to promote transversal competences. One action is focused on supporting the development of computational thinking in primary schools;
- to upgrade the technology curriculum in middle school and to promote digital competences required for the job market;

[4] Europe's Digital Progress Report (EDPR) 2017 Country Profile Italy, DESI, 2018
[5] https://www.agid.gov.it/sites/default/files/repository_files/documenti_indirizzo/agid_-_competenze_digitali_2016_r11.pdf
[6] http://www.crescereindigitale.it/
[7] https://www.eccellenzeindigitale.it/home

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- filling the gender gap in careers that involve competencies in STEM areas: according to the Ministry's data, only one out of three female students continue their high school studies focusing on STEM disciplines: Science, Technology, Engineering, Mathematics.[8]

In order to attract students to STEM for the job market, the Italian Ministry of Education has promoted the so-called **Piano Lauree Scientifiche**, a national plan that supports educational activities directed at encouraging careers in academic studies in the STEM areas, aiming at financing projects presented by university networks, in collaboration with schools. Universities are developing activities that directly involve high school students in laboratory practice. Another action of the plan aims to introduce innovative approaches for younger students in order to reduce school dropout.[9]

Evidences from the **Digital School Observatory** reveal that – with regards to Digital Competences – 74% of schools have activated digital citizenship pathways, 60% computational or robotic thinking, 59% digital creativity (e.g. creative writing and reading), 16% economics and entrepreneurship.[10]

Due to the importance of STEM, schools and universities – from both professors and students points of views – need to implement innovative ways in teaching/learning STEM programs. Following the **Opinion of the European Committee of the Regions — Strengthening STE(A)M education in the EU**[11], Italy is committed to integrate elements related to the arts, creativity and design in STEM learning approaches: this means not only to create a different acronym STE(A)M but also adopting an interdisciplinary approach. Students will be encouraged to take a systematic and experimental approach, as well as to use their imagination and make new connections among ideas. However, STE(A)M approach is still a relatively difficult approach to education and pose some problems, such as: difficulties in integrating lessons into the school time and resources; the need to prepare and support teachers in multidisciplinary teaching and

[8] *Science, Technology, Engineering and Mathematics Education Policies in Europe*, Scientix Observatory Report, European Schoolnet, Brussels 2018
[9] https://www.pianolaureescientifiche.it/
[10] https://www.miur.gov.it/web/guest/-/scuola-fedeli-piano-digitale-e-traino-per-innovazione-dai-laboratori-per-le-periferie-ai-fondi-per-il-registro-elettronico-i-prossimi-16-passi-
[11] *Opinion of the of the European Committee of the Regions — Strengthening STE(A)M education in the EU,* https://op.europa.eu/it/publication-detail/-/publication/8ca0e5cc-1280-11ea-8c1f-01aa75ed71a1/language-en/format-xhtml

the integration of STE(A)M into work programmes; finding methods to evaluate learning during this teaching process and results in different disciplines.[12] For these reasons, it still remains an elitist approach. Moreover, according to the "Education and training sector monitoring report 2018 Italy" prepared by the European Commission, **Italy spends less than other EU Countries in education and achieves worse results**. For this reason, but not only, Italy runs the risk of losing a million students in the next ten years: from 9 to 8 million in total.[13] Equally important is the **low participation of women in science**, both during school and in the working world: according to the report "*High Potentials in Tech-Intensive Industries: The Gender Divide in Business Roles*"[14] the abandonment rate in STEM sector after is much higher for women than for men. Causes include the lack of expectation of career advancement, the absence of support networks and the difficult work-life balance. To tackle this problem, the "She STEM European Award" was launched: an award system in which two female professionals in STEM sector are recognized for each member state of the European Union: a representative of a small company and a professional representative of a medium-sized company. The ultimate goal of this policy is to raise awareness of the human capital represented by women in STEM by supporting female talent.[15]

STE(A)M education is currently a priority of the Ministry of Education, especially in the sense of bridging the job shortage in STEM careers in Italy. In 2015 the Italian parliament approved Law 107/2015, commonly known as the Good School reform (*La Buona Scuola*). The law includes reforms regarding the teachers' recruitment, teachers' professional development, mandatory traineeships for all upper secondary students. An important stress on reforming curricula and improving digital skills was pointed out, particularly:

[12] *Da STEM a STEAM un nuovo approccio allo studio delle materie scientifiche a scuola con la "A" di Arte?* **,** http://www.erasmusplus.it/sondaggio-steam/
[13] *Education and Training MONITOR 2018 - Italy*, European Commission, 2018 https://ec.europa.eu/education/sites/education/files/document-library-docs/et-monitor-report-2018-italy_en.pdf
[14] Beninger, *High Potentials in Tech-Intensive Industries: The Gender Divide in Business Roles*, New York, Catalyst, 2014
[15] *Il "She STEM European Award": una politica europea per l'uguaglianza di genere e le pari opportunità nel settore STEM,* 24ore Mondo, 2019

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- Emphasis has been put on introducing or enhancing the teaching of certain subjects, such as economics, music, arts, law, sports, sustainable development, Italian, English and mathematical reasoning;
- The three-year National Plan for Digital Education (*Piano Nazionale Scuola Digitale*), aims to improve digital competencies of both teachers and students.[16]

In addition to these plans and policies, the Italian government is trying to improve its education systems by providing materials to support innovation and teaching reform. INDIRE (*Istituto Nazionale Documentazione, Innovazione e Ricerca Educativa*) has promoted the development of particular resources for STEM education for teachers: more than 800 resources developed for the main STEM subject areas and for different school levels are available in the "Scuolavalore" portal. The materials include reflections and theoretical insights, educational paths, video lessons, simulations, tutorials, suggestions to address specific learning difficulties, tests for assessing students' learning and self-evaluation of their courses for teachers.[17]

Beside national strategies, noteworthy are the many teachers' associations dealing with teaching improvement:

• UMI - CIIM (Italian Union of Mathematics): http://www.umi-ciim.it/

• AIF (Physics Teachers Association): http://www.aif.it/

• ANISN (Natural Sciences Teachers National Association): http://www.anisn.it/nuovosito/

• Accademia Nazionale dei Licei: http://www.lincei.it/

• National Association for physics teaching: http://www.aif.it/ [18]

[16] *La Buona Scuola*, Ministero dell'Istruzione, dell'Università e della Ricerca https://www.istruzione.it/allegati/2017/La_Buona_Scuola_Approfondimenti.pdf
[17] *Science, Technology, Engineering and Mathematics Education Policies in Europe*, Scientix Observatory Report, European Schoolnet, Brussels 2018
[18] Kearney, *Efforts to Increase Students' Interest in Pursuing Mathematics, Science and Technology Studies and Careers*. National Measures taken by 30 Countries – Report, European Schoolnet, Brussels, 2016

2. Integration of STE(A)M in schools

2.1 Good practices and ongoing national and international projects, resources, initiatives related to STE(A)M

Here below, a list of **National Level initiatives** to foster STE(A)M activities among students:

March: the STEM Month

The Italian Ministry of Education and Researches (MIUR) has launched a series of initiatives as part of the promotion of equal opportunities aimed at tackling gender stereotypes.

> **Target group**: young female students, teachers.
>
> **Aims**: the STEM Month is an initiative aiming at promoting the STEM (Science, Technology, Engineering, and Mathematics) disciplines in schools of all levels.
>
> **Procedural information**: on the 8th of March, International Women's Day, the *STEM: Female plural* competition[19] is therefore issued, which aims to encourage reflection on the presence of women in STEM disciplines, in order to encourage students to develop a critical reading of prejudices and gender stereotypes regarding science, technology, engineering and mathematics, and to encourage female students to study these subjects.[20]

Ricci Prize (*Premio Ricci*)

Target group: high school students, teachers.

Aims: to foster the teaching of STE(A)M disciplines and stimulate students' creativity.

Procedural information: it is a national competition addressed to high school students for the design and realization of an object conceived as a support (or complement) to the learning of scientific disciplines. The competition takes place every two years. The nature of the project to be submitted for the competition is not precisely defined: a mechanical or computer device

[19] http://istruzioneer.gov.it/wp-content/uploads/2019/03/Bando-STEM-2019_v2.pdf
[20] https://www.noisiamopari.it/site/it/mese-delle-stem/

illustrating one aspect of mathematics or its application, a series of posters or posters, interactive materials and tools.[21]

Archimedes Prize (*Premio Archimede*)

Target group: students, teachers.

Aims: to foster the teaching of STE(A)M disciplines and stimulate students' creativity.

Procedural information: the Archimedes Prize is a national competition and its main aim is the creation of new board games. The Prize is dedicated to Alex Randolph (considered the inventor of the profession of game inventors), who was its president for the first 7 editions. For aspiring inventors, it is not only an important showcase where they can showcase their creativity, but above all an opportunity to grow professionally by comparing their ideas with those of other authors and with the experts of the international jury.[22]

STEM*Lab – Search, Transmit, Excite, Motivate

Target group: students, students' families, teachers, educating community in general.

Aims: the main aim of the project is to strengthen in the partner regions (Sicily, Campania, Lombardy and Piedmont) the competences and aspirations of children through the acquisition of cognitive and non-cognitive skills.

Resource and activity: during this 4-years project, the activities that will be carried out are:

- Co-planning and training workshop for sharing and using an innovative educational methodology for teaching and learning STEMs and sharing of experiences
- Creation of STEM*Labs, multi-functional spaces capable of hosting educational activities, laboratories and events

[21] http://www.premioricci.unifi.it/
[22] https://www.studiogiochi.com/premio-archimede/ed-2020/

- Empowerment of families: programming aimed at students' families to extend the empowerment pathway initiated by the project to the entire family unit[23]

Local level initiatives:

Planetarium of Palermo – Villa Filippina

Target group: children, youth, students, teachers, scientific community in general.

Aims: to encourage the dissemination of scientific knowledge.

Procedural information: The Cultural Association URANIA a.c.s.d. manages "Il Planetario di Palermo" a museum and exhibition space of about 300 square meters, dedicated to Astronomy and Earth Sciences, for the public and schools, plus the outdoor spaces, terraces and lawn of the villa.

Resource and activity: the planetarium organises different events with schools and kids. Worth of mention is the event "Learn science and put it into art", during which the rooms of the planetarium have been enriched with paintings and photographic exhibition dedicated to naturalistic landscapes and with scientific exhibits dedicated to insects and volcanoes.[24]

PALERMOSCIENZA

Target group: children, youth, students, teachers, scientific community in general.

Aims: PALERMOSCIENZA is a project aiming at offering the possibility to experiment science communication activities in informal situations. The association PALERMOSCIENZA aims at the creation of a Sicilian Science Centre, which is not simply a physical space for exhibitions and laboratories but, above all, a space for a laboratory of ideas that allows different types of users to get in touch with the world of science.[25]

Robotic Team of the High School B. Croce: Robot.202 (Team Robotica del Liceo B. Croce)

Target group: high school students, teacher

[23] https://cesie.org/en/project/stemlab/
[24] https://planetariovillafilippina.com/
[25] https://www.palermoscienza.it/

Aims: the project aimed at fostering learning of disciplines such Mathematics, Physics and Computer Science. An upgrade path was planned, aimed at learning the contents necessary to carry out the “Mini-robot Race” promoted by the University of Catania scheduled for May 2019.

Procedural information: a project implemented by the High School Benedetto Croce and lasted one year.

When the Past becomes Future - From burning mirrors to solar power panels (Dagli specchi ustori alle centrali solari)

Target group: high school students, teachers, scientific community.

Aims: this one-year project, implemented by the High School Benedetto Croce aims at increasing the number of students enrolled in scientific faculties, to contribute to the construction of some European key competences, by fostering their knowledge in scientific subjects, as Mathematics and Physics. Moreover, it aims at strengthening students’ curricula and fostering continuity between high school and university and student orientation. Finally, the project aims at the realization of a technological product made by 30 students, to present at the National Ricci Prize.

Resource and activity: use of computer labs, two temperature sensors, two LCD displays, glue gun, MDF panel, 3D printings.

Teaching strategies: lectures, 6 hours of Mathematics lesson in English language, 14 hours for the laboratories.

Procedural information: the project provides for introduction to coding and robotics to foster the skills of students through the philosophy of "do it by yourself".

Scientific Degrees Project (*Progetto Lauree Scientifiche*)

Target group: high school students, teachers, scientific community.

Aims: the main aims of the project are:

- improving the knowledge and perception of scientific disciplines in high school, offering students in the last three years to participate in stimulating and engaging curricular and extra-curricular laboratory activities;

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- starting a process of joint work between School and University for the design, implementation, documentation and evaluation of the above-mentioned laboratories;
- promoting the optimization of training paths and the transition from School to University, strengthening and encouraging internship activities at universities, public and private research institutions and companies engaged in research and development.[26]

Procedural information: The Scientific Degrees Project is the result of a collaboration between the Ministry of Education, the National Conference of Science and Technology Department Deans and *Confindustria* (The General Confederation of Italian Industry). The project was born in 2004 with the aim to increase the number of students enrolled in the degree courses in Chemistry, Physics, Mathematics and Science; the educational guidance of students was carried out through more than 100 sub-projects.

Mathematic High School (*Liceo Matematico*)

Target group: students

Aims: the project analyzes the relationship 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. The aim is to provide students with knowledge and skills related to mathematics, so that they can consciously orient themselves in the different contexts of the contemporary world.

Procedural information: the *Liceo Matematico* project was launched in 2017 in Palermo. The courses of *Liceo Matematico* make use of the teaching methods and scientific contribution of professors of the University of Palermo and in particular of the Department of Mathematics and Informatics of the University of Palermo. The high school Benedetto Croce is involved in this project.[27]

[26] https://www.unipa.it/dipartimenti/matematicaeinformatica/Progetto-Lauree-Scientifiche/
[27] https://www.liceomatematico.it/palermo/

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2.2 International level

International programs in which CESIE is involved:

IN2STEAM - Inspiring Next Generation of Girls through Inclusive STE(A)M Learning in Primary Education.

Erasmus+ project coordinated by CESIE.

Target group: students' (with a focus on female students), teachers and educators, children.

Aims: it aims at increasing the competence development of teachers and educators to teach and expose STE(A)M concepts to young children at primary school, with a focus on girls, in order to foster creativity, critical thinking and problem-solving competences. The target group is composed by children and educators.

Procedural information: the project will last three years.

Resource and activity: during the duration of the project the following tools will be developed:

-Research study on the value of STE(A)M education;
-Online training modules, guidelines tools and methodologies to increase the competence development of teachers and educators to effectively introduce STE(A)M approaches in their classroom at primary school;

-Testing of the Digital Teacher's Toolkit and the Activity KIT with the pupils through a cycle of IN2STEAM Labs with the collaboration of female STE(A)M professionals and arts practitioners;
-Organisation of 6 "Science Days" in each partner country, with the involvement of schools, teachers, educators, parents, STE(A)M professionals and stakeholders;
-Elaboration of a "European Charter for STE(A)M Education" with policy recommendations that

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will support schools with intervention strategies and common framework to support the behavioural change in girls to foster non-gender stereotyping in education and career choices.[28]

FemSTEM - Coaching-Recruitment, Retention and Progression Coaching for Women in STEM: a project co-founded by the Erasmus+ programme of the European Commission in which CESIE is involved.

Target group: women and professionals in the field of STEM

Aims: the main objectives of the project are:

- to create a comprehensive approach to deliver interventions to address the challenges faced by women during the Recruitment, Retention and Progression stages;
- to develop an E-Coaching programme for women in STEM;
- to develop a face-to-face peer coaching programme for women in STEM;
- to increase women's self-confidence, self-efficacy and develop their soft skills and employability skills.

Resource and activity: Recruitment, Retention and Progression (RRP) Framework testing; E-Coaching Programme that supports the learners in using digital technology in creative, collaborative and efficient ways and inspires new ways of thinking. An in-depth research on the barriers that women face in the labour market in all partner countries has been carried out; moreover, the development of the E-coaching programme for women in STEM, and other initiatives useful for women in STEM has been launched.

Teaching strategies: Coaching Circles methodology includes coaching, mentoring and action learning techniques to help the participants reach your goals with the support of an experienced facilitator and a small group of peers.

[28] https://cesie.org/en/project/in2steam/

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Procedural information: the project will last three years and it involves Countries as UK, Italy, Greece, Luxembourg, Spain.[29]

FeSTEM - Female Empowerment in Science, Technology, Engineering and Mathematics in Higher Education: a project co-founded by the Erasmus+ programme of the European Commission in which CESIE is involved.

Target group: female students, teachers and educators

Aims: it aims to promote an innovative method and pedagogy that will allow HE students to use traditional and computationally-rich media to create meaningful, shareable exhibits that will act as mentoring models for encouraging girls and women to remain active in STEM.

Resource and activity: A Research on academic and industrial levels into the challenges and expectations of women in STEM was carried out. Development of a toolbox with traditional and digital materials for constructing gender-sensitive exhibits. The FeSTEM community platform, aiming at linking HE students in STEM with experienced mentors in the field.

Teaching strategies: FeSTEM methodology: a gender-sensitive curriculum for STEM that consists of a set of training methodologies that can be used for guiding gender-sensitive teaching and the FeSTEM approach that informs the training methodology. At least 20 teachers and students will participate in transnational learning, teaching and training activities.

Procedural information: the project will last two years and it involves Countries as Cyprus, Greece, Italy, Slovenia and Spain.[30]

[29] https://femstem.eu/
[30] https://festemproject.eu/

A2.2 Analysis students' attitudes and teachers' approaches towards STEM learning and teaching

Overview of the questionnaires

The first questionnaire is addressed to ***13-18-year-old students*** and it is aimed at identifying the students' attitudes towards STEM subjects, also regarding their choices in their University/career paths.

~~It is available in Italian on Google forms here~~

The second questionnaire is addressed to ***secondary schools' teachers and directors*** and it is aimed at identifying the teachers' approaches towards STEM and non-STEM subjects.

~~It is available in Italian on Google forms here~~

Data collected from students' questionnaires

The questionnaire was completed by **289 students** from P2 **"Liceo Scientifico Benedetto Croce"** of Palermo. The **age of students** goes from 13 years old to 18 years old; the majority of students (26.6%) are 15 years old, followed by 18 years old students (23.5%) and 14 years old (20.8%). Regarding **students' gender:** more than half of students are male students (55.4%); the other 44.6% are female students.

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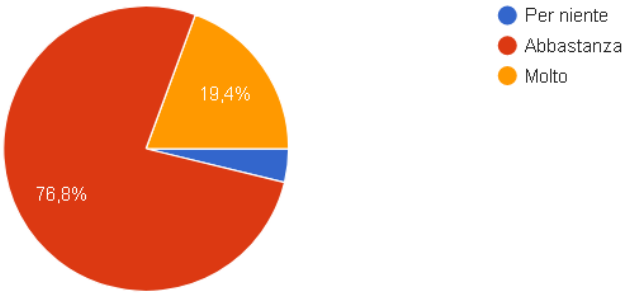
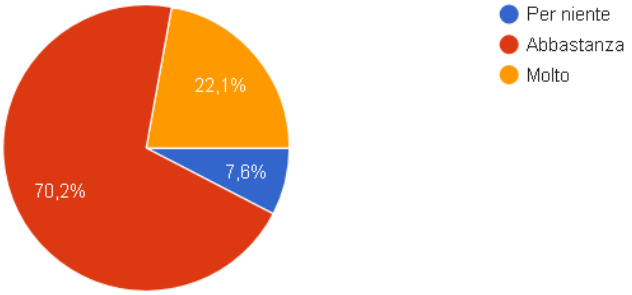
- Regarding the question **(5) How confident are you that you are able to ask questions about a phenomenon or define a problem that needs to be solved?** 76.8% of students claim they are fairly confident. Only a very low percentage of students answer they are not confident at all (3.8%).



(6) How confident are you that you are able to plan and carry out investigations? To this question, 70.2% of students answer they are fairly confident; 22.1% are very confident and only 7.6% answer they are not confident at all.



- **(7) How confident are you that you are able to analyse and interpret data?** 73.7% of students say they are fairly confident in analysing and interpreting data; only a low percentage of 5.5% are not able at all in doing it.

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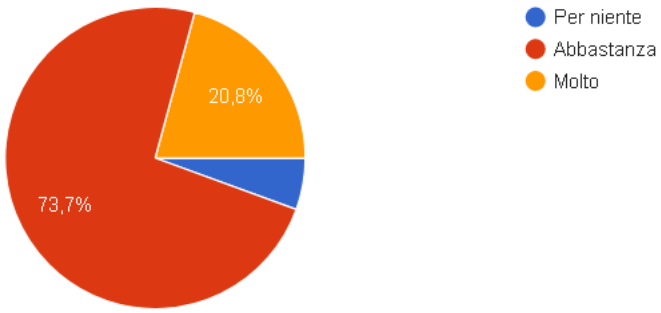
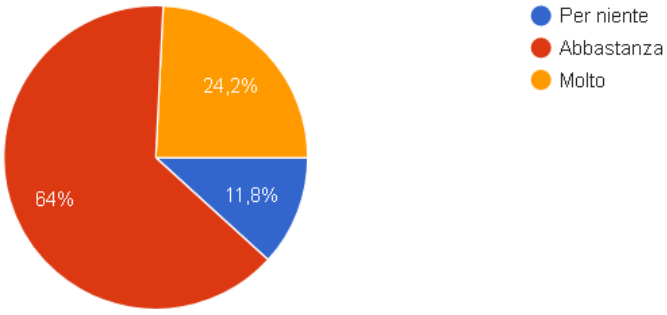


- **(8) How confident are you that you are able to use mathematics and computational thinking?** To this question, the majority of students reply they are fairly confident (64%); 24.2% reply they are very confident. Only 11.8% answer they are not confident at all.



- Regarding students' abilities in **(9) building explanations about a phenomenon or designing solutions for a problem, (10) finding evidences that help students to reason and argument and (11) obtaining, evaluating, and communicating information** the majority of them (more than 60%) are very confident in doing it.

- **(12) I get good grades at science, technology and/or mathematics:** 69.6% of students have quite good grades in these subjects; **19.4% have very good grades;** on the other hand, 11.1% claim they don't have good grades at all.

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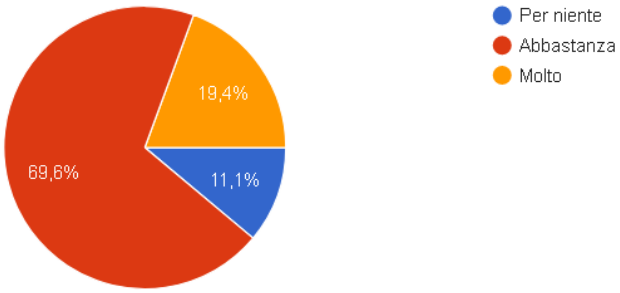
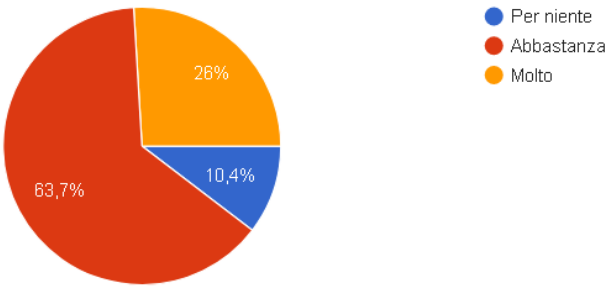
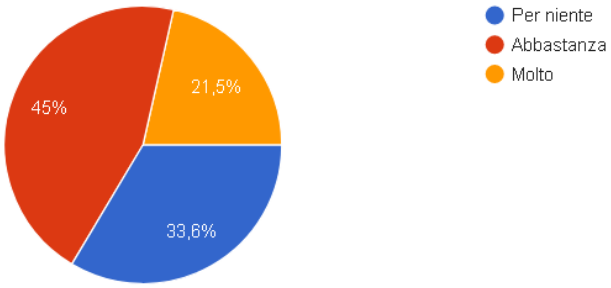


- Regarding questions **(13) I understand everything in my science, technology and/or mathematics lessons and (14) I find science, technology and/or mathematics easier than theoretical subjects,** the majority of students find these subjects fairly easy to understand, even if the percentage of students that have difficulties is high (33.6%).





- 22.1% of students answer they **(15) look forward to science, technology and/or mathematics lessons.**

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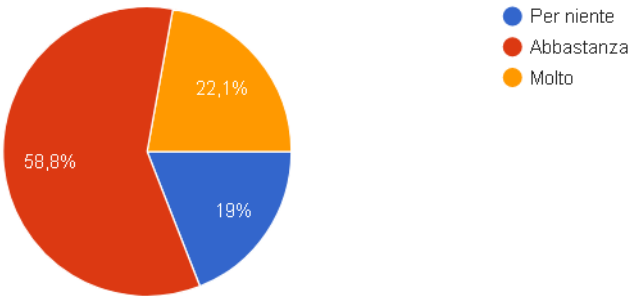
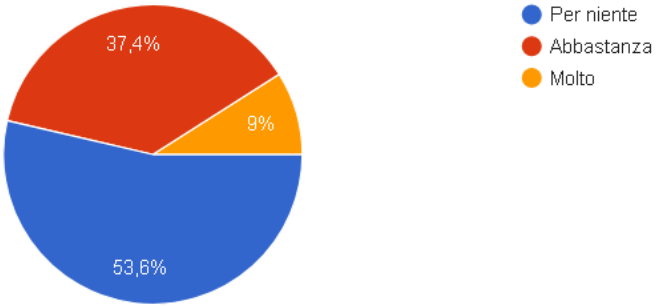


- **(16) For my future job it is important to me to work with mathematics rather than people:** 53.6% of students don't agree with this statement; only 9% of students believes that for their job mathematics will be more important than people.



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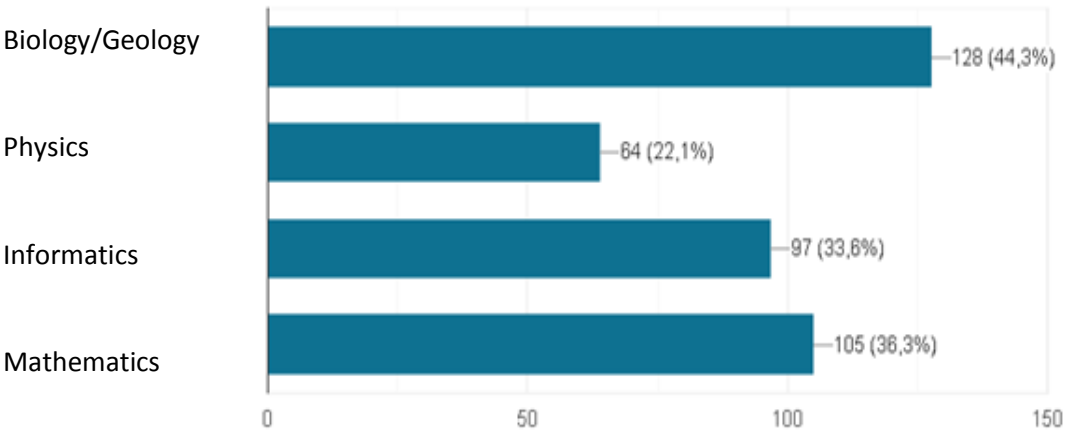
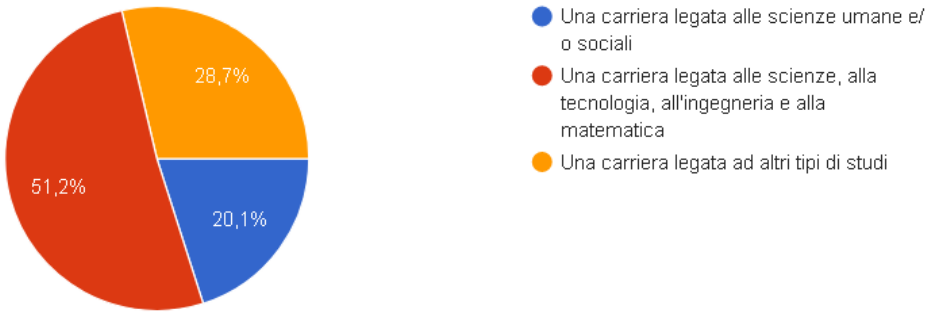
- Regarding science and technology subjects, 44.3% of students are oriented toward Biology/Geology subjects, 36.3% of students are oriented toward Mathematics, 33.6% are oriented toward Informatics and finally 22.1% are oriented toward Physics.

  (17) Think about science and technology subjects. Which of them do you feel you are capable and willing of studying in the future?



- Students claim that – according to their teachers – they could be good students of **(A) a career related with humanities and/or social sciences** (20.1% of students), **(B) a career related with science, technology, engineer and mathematics** (51.2% of students) **or (C) a career related with other type of studies** (28.7% of students).

  (18) I think that my teachers consider that I will be a good student of… (select the best option)



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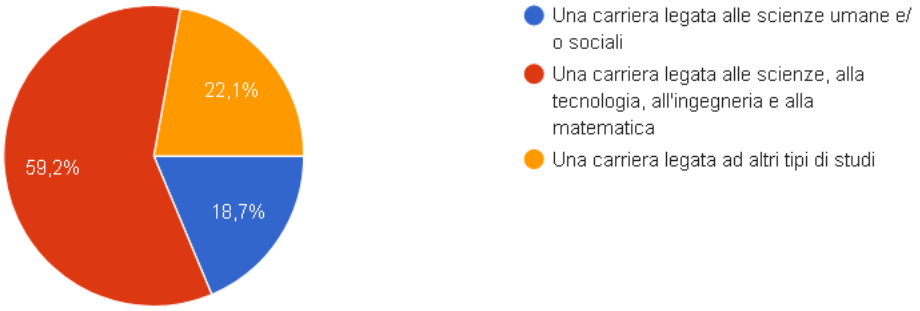
- Students claim that – according to their parents' opinion – they could be good students of **(A) a career related with humanities and/or social sciences** (18.7% of students), **(B) a career related with science, technology, engineer and mathematics** (59.2% of students) **or (C) a career related with other type of studies** (22.1% of students) .

  (19) I think that my parents consider that I will be a good student of… (select the best option)



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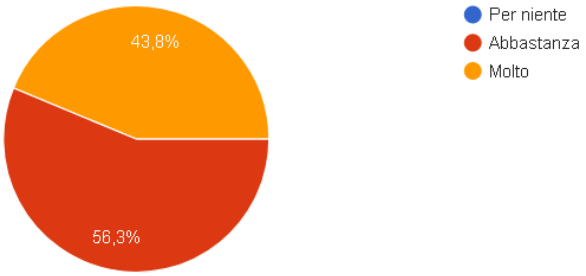
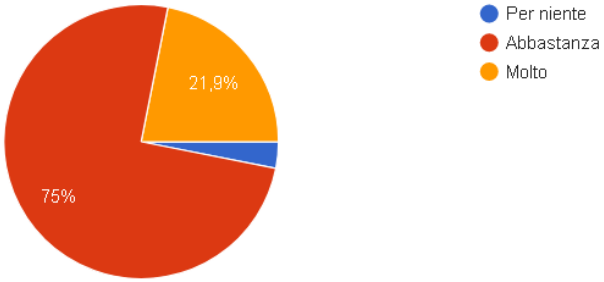
Data collected from teachers' questionnaires

The questionnaire has been completed by 33 professors from P2 **"Liceo Scientifico Benedetto Croce"** and other secondary schools of Palermo. the majority of professors are between 50 and 59 years old (43.8%) with a strong prevalence of female professors (68.8%) compared to a 31.3% of male professors.

- **(5) How confident are you that you are able to ask questions about a phenomenon or define a problem that needs to be solved?** To this question 43.8% of professors answered "very confident" and 56.3% answered they are "fairly confident".



- **(6) How confident are you that you are able to plan and carry out investigations?** The majority of professors (75%) claim that they are fairly confident to do it; 21.9% very confident and a low percentage 3.1% – which means just one professor – is not confident at all.



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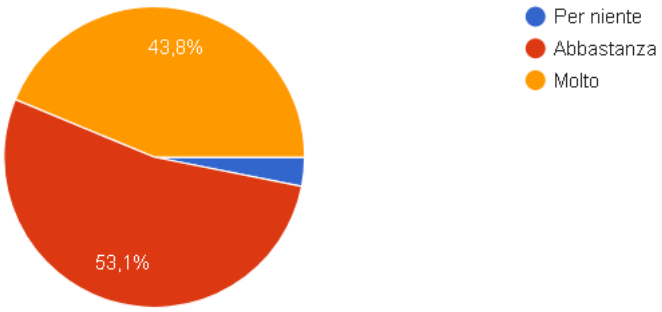
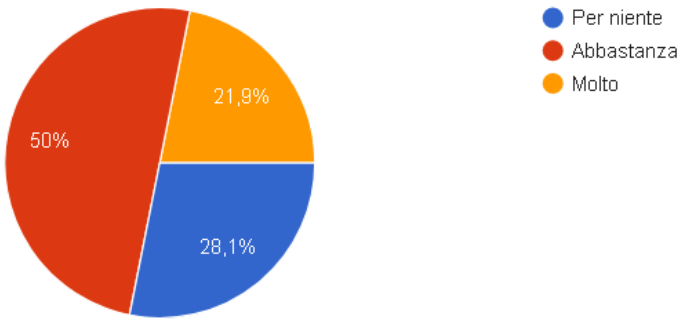
- **(7) How confident are you that you are able to analyse and interpret data?** 53.1% of professors claim that they are fairly confident in analysing data; 43.8% say very confident. Just one professor, who represents the 3.1% – say he/she is not confident at all.



- **(8) How confident are you that you are able to use mathematics and computational thinking?** 50% of professors say they are fairly confident in using mathematics and computational thinking; the other 21.9% say they are very confident. The remaining 28.1% claim they are not able at all in using mathematics and computational thinking.



- **(9) How confident are you that you are able to build explanations about a phenomenon or design solutions for a problem?** The big majority of professors (71.9%) claim they are fairly confident in building explanation about a phenomenon or designing solutions; the other 25% of professors define themselves “very confident”. Just one professor say he/she is not confident at all.

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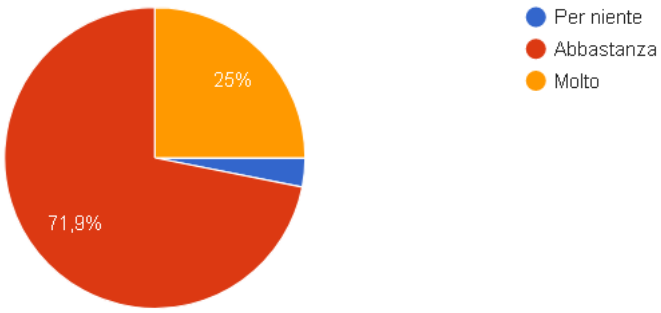
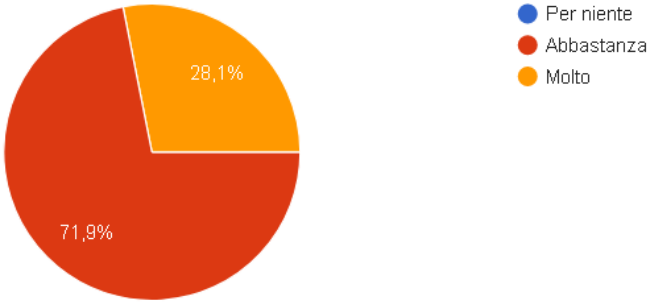


- **(10) How confident are you that you are able to find evidences that helps you to reason and argument when finding the best explanation to a phenomenon or the best solution to a problem?** 71.9 of professors define themselves as fairly confident in finding evidences and explanations to a phenomenon; the remaining 28.1% say they are "very confident".



- **(11) How confident are you that you are able to obtain, evaluate, and communicate information?** To this question, 65.6% of professors reply they are "fairly confident"; the remaining 34.4% of professors reply they are "very confident".

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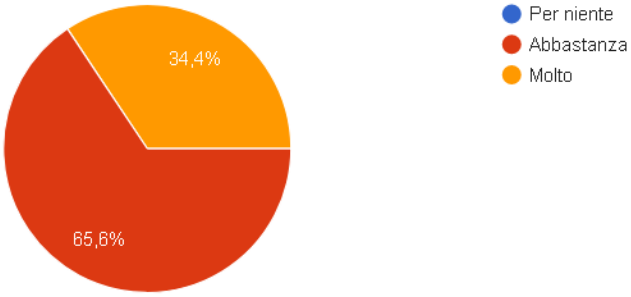
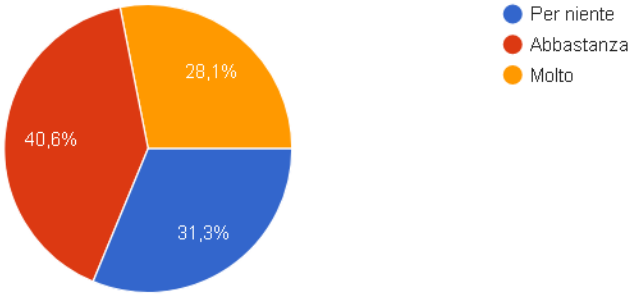


- **(12) How confident are you that you are able to explain the STEM content of the subject/ project/ workshop to participant teens?** 40.6% of professors reply they are fairly confident in explaining STEM content; 28.1% of professors define themselves as "very confident". The remaining 31.3% say they are not confident at all in explaining STEM content to students.



- **(13) How confident are you that you have sufficient knowledge of STEM subjects to answer participant teens' questions during your lesson/workshop?** To this question, 46.9% of professors reply they are "fairly confident"; 18.8% say they are "very confident". The remaining 34.4% claim they are not confident at all.

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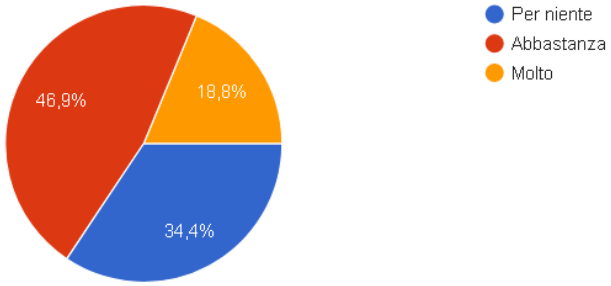
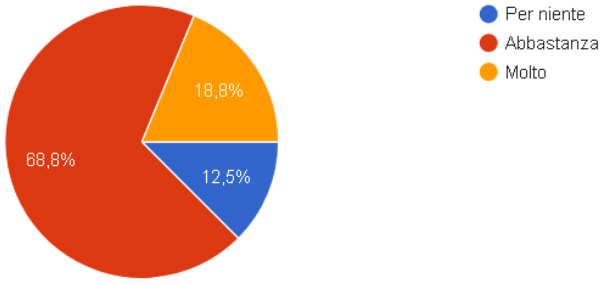


- **(14) How confident are you that you are able to use a variety of teaching approaches or strategies to develop your cognition of mathematics/science/technology concepts?** 68.8% of professors say they are confident to use different teaching approaches or strategies; 18.8% say they are “fairly confident”; the remaining 12.5% are not confident at all.



- **(15) I am familiar with the whole structure and directions of the lesson/project/workshop.** 50% of professors are very familiar with the whole structure and directions of the lesson/project/ workshop; 31.3% are “fairly familiar” and 18.8% are not familiar at all.

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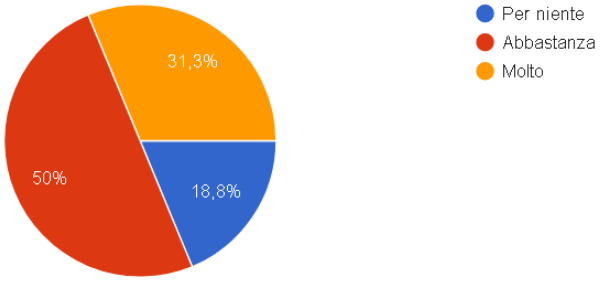
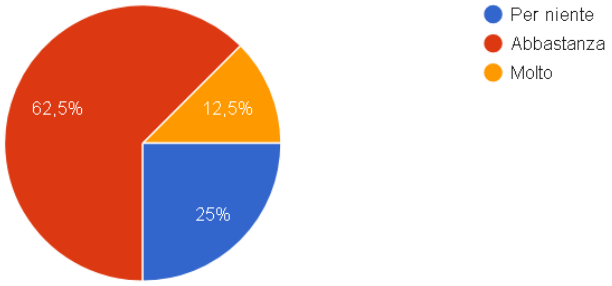


- **(16) I can select effective teaching approaches to guide student/teens thinking and learning in mathematics/science/technology.** 62.5% of professors are fairly able to select effective teaching approaches to guide student/teens thinking and learning in mathematics/science/technology. 12.5% of professors define themselves as "very able". Finally, the remaining 25% say they are not able at all.



- **(17) I use a variety of teaching approaches or strategies to raise teens' confidence in their capacities to perform successfully STEAM activities.** 15.6% of professors use a variety of teaching approaches or strategies to raise teens' confidence in their capacities to perform successfully STEAM activities; 59.4% use them fairly. Finally, 25% of professors do not use them at all.

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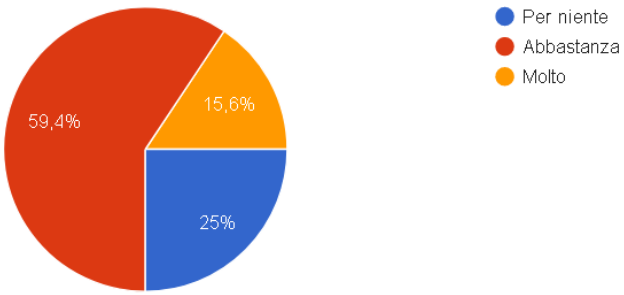
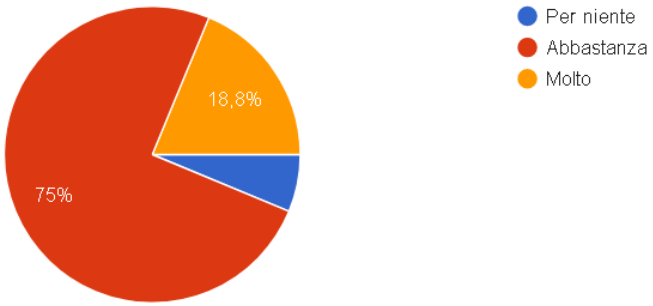


- **(18) I know how to choose effective teaching approaches to guide students' learning and thinking.** 75% of professors say they are fairly confident in choosing effective teaching approaches to guide students' learning and thinking. 18.8% say they are "very able" and just two professors say they are not able at all.



- **(19) I can adapt my teaching style to different learners.** 75% of professors are able to adapt easily their teaching style to different learners; the remaining 25% say they are fairly able.

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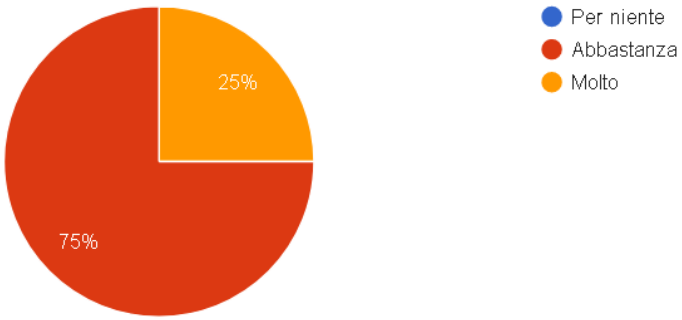
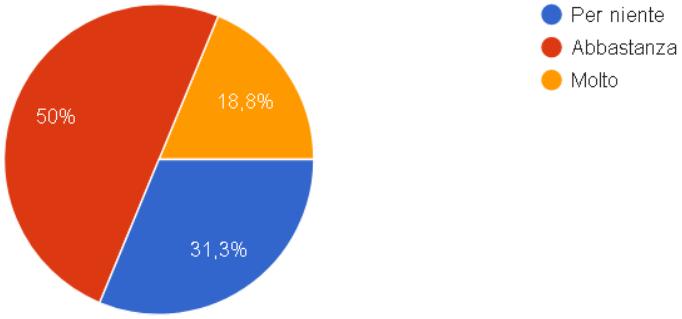


- **(20) I am familiar with common student understandings and misconceptions of the STEM content I am teaching.** 50% of professors are fairly familiar with common student understandings and misconceptions of the STEM content; 18.8% are very familiar and 31.3% are not familiar at all.



- **(21) I can create a classroom setting to promote students' interest for learning STEM concepts.** The majority of professors (68.8%) reply they are fairly confident in creating a classroom setting to promote students' interest for learning STEM concepts. The remaining 12.5% are very confident and 18.8% of professors are not confident at all.

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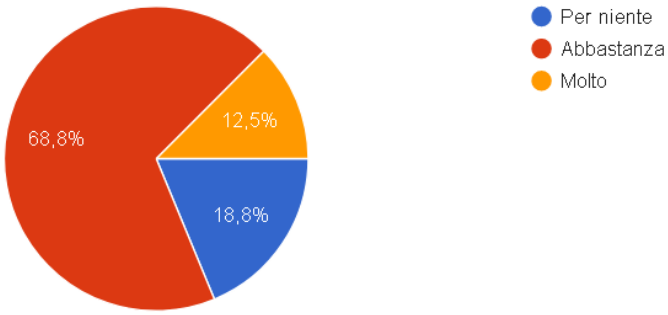
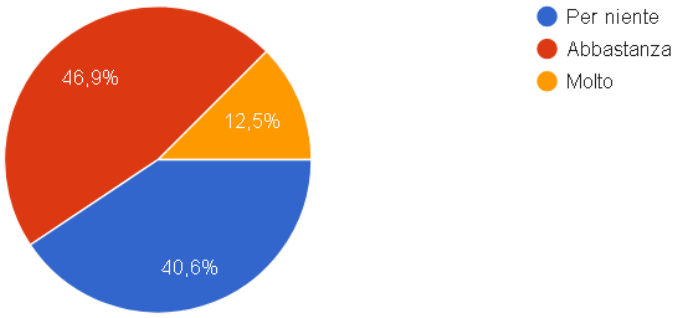


- **(22) I know the steps necessary to teach STEM concepts effectively.** 46.9% of professors say they fairly know the steps necessary to teach STEM concepts effectively; 40.6% are not confident at all. 12.5% of professors know very well the steps necessary to teach STEM concepts effectively.



- **(23) I find it easy to explain to students why STEM experiments work.** 59.4% of professors can fairly explain to students why STEM experiments work; 34.4% are not confident at all.

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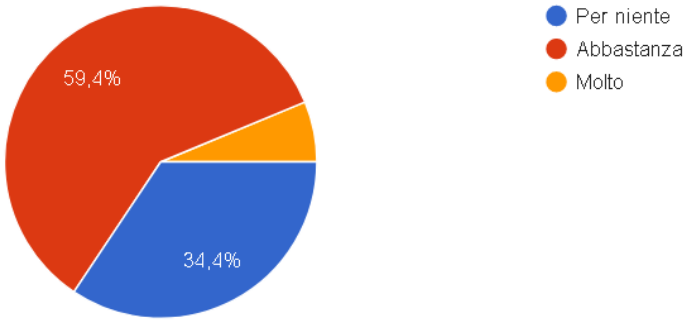
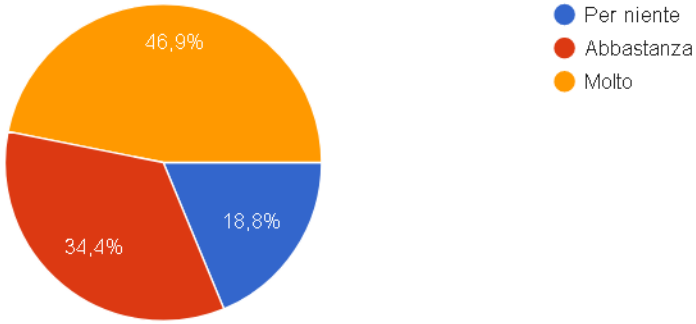


- **(24) When teaching STEM, I usually welcome students/teens questions.** To this question, professors reply that students' questions are welcomed during classes; 46.9% of professors say questions are very welcome. 18.8% say they are not welcome at all.



- **(25) I am able to effectively teach STEM content to teens/students whose first language is not Italian.** 37.5% of professors are fairly able to teach STEM content to teens/students whose first language is not Italian; nonetheless, the majority of them is not able to do it (56.3%).

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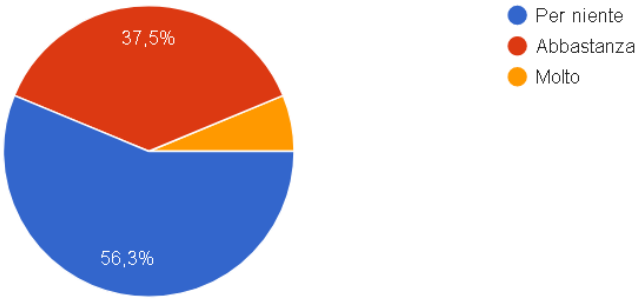
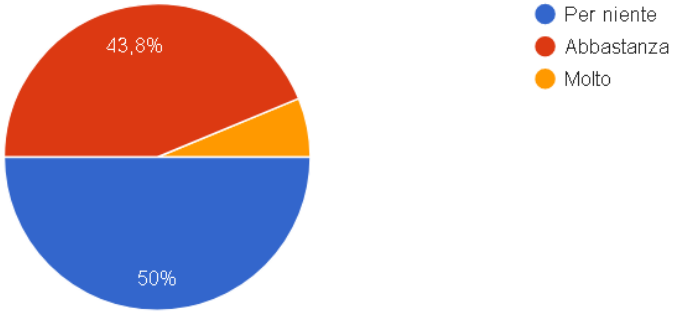


- **(26) I can do a great deal as a teacher to increase the achievement of STEM subjects of children who do not speak the national language as their first language.** 50% of professors claim they are not able to increase the achievement of STEM subjects of children who do not speak the national language as their first language. 43.8% say they are “fairly able”.



- **(27) I have the ability to help teens from low socioeconomic backgrounds be successful in STEM.** 71.9% affirm they are fairly able to help teens from low socioeconomic backgrounds be successful in STEM. On the other hand, the remaining 28.1% affirm they do not have this ability at all.

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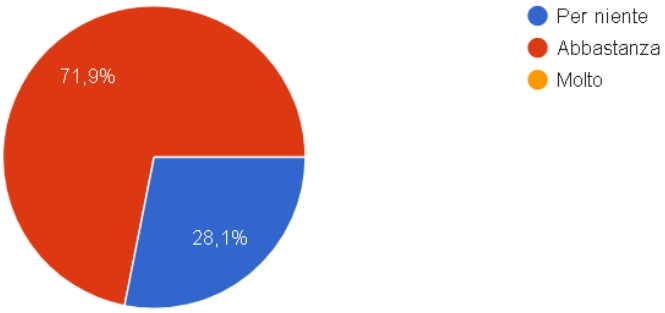

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Conclusions

The teaching of STE(A)M subjects is increasingly important within the Italian and European school system: in recent years, we have witnessed an increasing interest from institutions, which aim to strengthen the teaching of these subjects, closely linked to growth, economy and the job market. In last years, indeed, the Italian government launched different national plans and coalition, in order to attract students and to reduce the abandonment rate of the female students in these fields. Nevertheless, the Italian government is still one of those which invest less in education in Europe and it achieves worst results compared to other European Countries. Despite the few investments, we have collected several examples of best practices at international, national and local level, in which the focus is on the inclusion of female students in STE(A)M activities and the promotion of STE(A)M activities inside and outside the schools (the Planetarium of Palermo mentioned above or "Palermoscienza").

Based on the data collected from the students' questionnaires from the high school Benedetto Croce, regarding STEM subjects, students feel themselves fairly confident in subjects as mathematics, biology, chemistry, informatics and physics. The majority of them (around 60-70%) are fairly confident in mathematics and using computational thinking and in analysing and interpreting data. In general, students are interested in STEM subjects, especially Biology/Geology and followed by Mathematics and Informatics. Students affirm they have fairly good grades in STEM subjects and they are interested in STE(A)M approaches; overall, 53.6% of students don't believe mathematics is more important than people; only 9% of students believes that for their job mathematics will be more important than people.

Based on the data collected from teachers' questionnaires from the high school Benedetto Croce, professors in general define themselves "fairly confident" in analysing and interpreting data, in planning and carrying out investigations and using mathematics and computational thinking.

Professors can easily adapt their teaching style to different students (75% of professors are able to adapt easily their teaching style to different learners; the remaining 25% say they are fairly able) and they are fairly confident in creating a classroom setting to promote students' interest for learning STEM concepts. 50% of professors claim they are not able to increase the achievement of STEM subjects of children who do not speak the national language as their first language and that they are not able to teach STEM content to teens/students whose first

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language is not Italian. To conclude, the majority of them (71.9%) affirm they are fairly able to help teens from low socioeconomic backgrounds be successful in STEM. Regarding the teaching of STE(A)M subjects, the majority of professors feel “fairly confident” in teaching STE(A)M subjects to students, as well as in the direction of lesson/project/workshop and in obtaining, evaluating, and communicating information.

”Liceo Scientifico Benedetto Croce”, partner of the CHOICE project, is one of the biggest high school of Palermo for scientific subjects; it is located in the historical centre of the city of Palermo, close to different neighborhoods where there are high percentage of multi-ethnicity. Due to this, the percentage of foreign students within the school is fairly high; that’s why we wanted to stress the ability of professors to teach their subjects to students who do not speak Italian as first language

The attention posed on the teaching of STE(A)M is growing more and more in recent years. Both students and professors are interested in new learning/teaching approaches, more inclusive, innovative and groundbreaking. The good practices selected offered the possibility to get involved in STE(A)M activities to all students, regardless their economic and social background and gender; indeed, as the report mentioned above, great attention is paid on the inclusion of female students more than before.

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3.1 Sitography

- Crescere in digitale http://www.crescereindigitale.it/
- Eccellenze in digitale https://www.eccellenzeindigitale.it/home

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- FemSTEM - Coaching-Recruitment, Retention and Progression Coaching for Women in STEM https://femstem.eu/
- FeSTEM - Female Empowerment in Science, Technology, Engineering and Mathematics in Higher Education https://festemproject.eu/
- IN2STEAM - Inspiring Next Generation of Girls through Inclusive STE(A)M Learning in Primary Education https://cesie.org/en/project/in2steam/
- Liceo Matematico https://www.liceomatematico.it/palermo/
- Piano Lauree Scientifiche https://www.pianolaureescientifiche.it/
- Planetarium of Palermo – Villa Filippina https://planetariovillafilippina.com/
- PALERMOSCIENZA https://www.palermoscienza.it/
- Progetto Lauree Scientifiche https://www.unipa.it/dipartimenti/matematicaeinformatica/Progetto-Lauree-Scientifiche/
- Scuolavalore http://www.scuolavalore.indire.it/
- STEM*Lab – Search, Transmit, Excite, Motivate https://cesie.org/en/project/stemlab/

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