ENGIE DELIVERABLE 1.4

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INTERNATIONAL BEST PRACTICE REPORT ON TEACHING STEM

Summary

This report presents the results of the review aimed at identifying best practices and success stories relative to STEM teaching in Europe and worldwide, in the framework of WP1 “Programming”, tasks 1.3 and 1.4

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ENGIE DELIVERABLE 1.4

Table of contents

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

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Introduction

The problems linked to the shortage of skilled employees in key scientific professions and the need for modernizing science teaching in schools have become crucial in recent years, as evidenced by several publications (e.g. DeHart Hurd, 2002; Butz et al., 2003; Radant et al., 2016; Benedek et al., 2020). The recruitment crisis in Science, Technology, Engineering and Mathematics (STEM) professions is particularly worrying for the European Union (EU), as it needs to deepen its innovation capability to compete on global markets and maintain or improve the European way of life. Indeed, at the global level, the EU has a performance lead over the United States, China, Brazil, Russia, South Africa, and India, but this gap has become smaller in the last decade, with China catching up at five times the EU's innovation performance growth rate (EIS, 2020). Moreover, the increasing dependence on resources (i.e. raw materials) from abroad, is making the EU highly vulnerable to market oscillations originating from strategic choices made by other countries (Giljum & Hinterberger, 2014). The need of skilled professionals in scientific fields related to raw materials' exploitation, disposal, recycling and related environmental problems is then more urgent than ever. The challenges are even greater for the recruitment of young girls in Engineering and Geosciences careers (Millward et al., 2006; Lahiri-Dutt, 2011), both closely linked to raw materials' scientific/productive fields, but traditionally considered as masculine. The recruitment crisis in Geoscience disciplines is therefore worsened by this evident gender imbalance. This latter must be overcome in order to achieve higher levels of creativity and innovation that usually accompany heterogeneous and diverse teams (Egan, 2005; Beigpourian & Ohland, 2019).

The project 'ENGIE – Encouraging Girls to Study Geosciences and Engineering' aims to turn the interest of 13-18 years old girls to study specific STEM disciplines: Geosciences and related Engineering. As career decisions are school-mediated and made generally in this period of life (Sasson, 2020), the project is expected to contribute in improving the gender balance in the fields of these disciplines. One of the challenges that the project had to face was the shortage of knowledge on how to effectively encourage and sustain a young woman's (and teenage student's in general) interest in STEM. ENGIE has addressed this issue by conducting research and gathering comprehensive knowledge on what keeps girls and boys away from Geosciences and Engineering. As a starting point, ENGIE deliverable D1.1 (Report on baseline assessment) presented the results of the survey on the interest of secondary school students for geosciences (Johansson, 2020). The aim of the survey was to identify obstacles impending young women to embark on a geoscientific career as well as to assess the status of geo-education in secondary school more generally. Interestingly, not more than half of the teachers perceived the underrepresentation of women to be a problem in need of addressing, but preliminary data analyses indicate that teachers highlight

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on one hand a general need to increase and promote geo-education in secondary school, and on the other hand the need to specifically promote women role models.

As a further development, an extensive research on best programs and practices to increase the interest for STEM disciplines of students in general, and girls in particular, was developed in the framework of Work Package (WP) 1 “Programming” through tasks 1.3 and 1.4, with the aim of collecting best practices and success stories as a contribution to the customization of the ENGIE Action Plan (Task 1.5). This report presents the information gathered in this context.

Task 1.3 (International benchmarking) focused on best practices on the mobilisation of girls and women in geosciences in technologically advanced countries and comprised literature studies, direct surveys, historical evaluation of successful programs and initiatives. Task 1.4 (Best practice methods in Europe for STEM) reviewed past and current actions in Europe and worldwide aimed at raising girls’ (and also male students’) interest for STEM (in general) and other STEM-related yet specialized campaigns (such as ICT or engineering). Projects and initiatives were reviewed both on national and EU level with the purpose of adapting their scope and replicating their successes within the field of geosciences and geo-engineering. They were selected after widespread searches on the web and through direct experiences by several project partners. The focus was on Europe but similar successful approaches and/or initiatives developed outside its borders were identified and have then been included in this report as they provided inspirational examples of best practices for STEM teaching.

Results are presented as entries of a dataset where each initiative/project/program/study is described in a devoted form accompanied by a short comment on how it could be tailored for ENGIE’s scopes. Literature references or accessed websites are also reported

Entries are grouped in three categories: 1) Theoretical concepts that underlie best practices for STEM teaching; 2) Programs and projects for schools and the general public; 4) Initiatives/actions aimed at girls and women.

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1. Theoretical concepts that underlie best practices for STEM teaching

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1.1. Affective Domain and Individual Interest

Description

A theoretical model is proposed that engage the affective domain (emotion, attitude, and motivation) to motivate student learning of geosciences. The model components are motivation and emotion (both coming from the field of educational psychology), and a third term that involves the "connections with Earth" (coming from environmental education and art education fields), meaning the affective ties that all human beings feel with the material environment. When all three of these components are combined in the classroom, students may experience greater interest in and connection to the content. The integration of cognition and affection in learning is a needed moment in educational curriculum reform. It becomes important for geologists involved in dissemination activities to clearly state why they chose this profession and why they love it, in this way they evidence their connection with Earth that can be shared with the students. This connection may lead to greater motivation to learn and value the content. Three strategies have been proven to successfully enhance student learning in geoscience education: 1) Peer instruction with formative assessment using Concept Tests (a method of cooperative learning strategies); 2) Field-based experiential learning, and 3) Place-based learning, i.e. experiences promoted in local environments and communities. Way of assess the motivation, emotion, and connection with the Earth rely on Motivated Strategies for Learning Questionnaires (MSLQs), Self-Efficacy Questionnaires (SEQs) and surveys.

Then, the interest initially triggered with this model can become maintained situational interest, if supported, ultimately leading to individual interest progressing from emerging to well-developed. The interested students (first stage) will not develop into a more sustained individual interest unless it is repeated, engaging and intellectually stimulating.

Lessons learned for ENGIE:

The passionate successful women to be interviewed in ENGIE project might be the way to provide the "connection to the Earth" term of the affective domain model. All three strategies that have been successfully used to enhance student learning (i.e. peer work, field and place based learning) need to be activated in ENGIE actions. Concept tests rely on prosocial goals that are especially suited for girls who aims at interacting with others.

van der Hoeven Kraft (2017).
van der Hoeven Kraft et al (2013).

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1.2. Communicating geosciences at the Solomon Islands

Description

Examples of communication of geoscience topics to indigenous people in the Solomon Islands have originated generic best practice advices. In particular, discussed topics were relative to land access, a live volcano event, the setting up of a gold mine, and raising awareness of volcanic hazard.

Best practice advices include: 1) the understanding of indigenous culture, 2) involvement at every level of the communication process; 3) inclusion of all stakeholders; 4) a clear message; 5) a face to face communication procedure; 6) the involvement of the community in practical exercises, 7) a thorough follow-up and evaluation process, and 8) sufficient time to allow the process to be effective

Lessons learned for ENGIE:

When translated to teenagers and their "world", the best practices identified in this work well apply to ENGIE's aim and scope, especially 1, 4, 6 and 8.

Petterson et al (2008)

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1.3. Research Partnership Consensus Statement

Description

The following statement describes the benefits of developing research partnership between scientist and society, in particular K-16 students (from pre-school to bachelor's degree) and teachers:

"Research partnerships between scientists and K-16 students, teachers, and the general public can increase our collective understanding of the Earth system while making the science by which we understand the Earth accessible to all. Partnerships promoting authentic research integrate inquiry-based educational approaches with innovative research questions. Such partnerships serve as effective vehicles for teaching scientific logic, processes, and content, while allowing students to participate fully in scientific investigations. Benefits to the scientists include data collection and analysis that may be difficult to gather with limited human resources, and an opportunity to engage the next generation of scientists. Benefits to the students and teachers include a learning process that fosters creativity, sets high standards, teaches problem solving, and is highly motivating. When closely aligned with the National Science Education Standards, research partnerships should be an integral component of science education reform at all levels. This potential will be achieved only if partnerships are effectively evaluated from both pedagogical and scientific perspectives, and best practices are widely disseminated and supported by both scientific and educational communities."

Lessons learned for ENGIE:

It is advisable that participant to the ENGIE project will work in the direction of developing a similar partnership with students and teachers for mutual benefits.

Harnik & Ross (2003).

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1.4. Constructivist approach to Science education

Description

The constructivist approach to science education is recognized as a valuable approach for building deep student understanding of scientific content and inquiry. It is attained through inquiry -based exercises that differ from traditional laboratory exercise when they try to simulate the real open-end work of a researcher that is often characterized by on-the-run fails instead of immediate successes.

Teaching through the constructivist approach means that students might need more time to incorporate new ideas, therefore it is suggested to limit the breadth of content taught while introducing them to the scientific inquiry method. Pitfalls of group work should be avoided.

Lessons learned for ENGIE:

A constructivist approach might be difficult to be developed in the framework of ENGIE actions, nevertheless the suggestion to limit the breadth of content introduced during the activities with schools might be a good one in favor of a deeper insight of specific topics.

Riggs & Kimbrough (2002).

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1.5. Geoethics

Description

All geoscience practices have evident repercussions on society. This implies ethical obligations to which geoscientists must conform. The adoption of ethical principles is essential if geoscientists want to serve the public good in the best way. Ethical responsibility by all geoscientists requires a more active role while interacting with society. Geoethics, which investigate the ethical, social and cultural implications of geoscience research, practice and education, represents a new way of thinking about and practicing Earth sciences, focusing on issues related to the relationship of the geoscientist with the self, colleagues, and society in the broadest sense.

Lessons learned for ENGIE:

All actions promoted in the framework of the ENGIE project must refer to the geoethics principles, specifically those related to geo-education, i.e. the transfer of geological knowledge to the public with the aim of raising awareness about how the geosphere operates and evolve. The use of an easy language and of precise tools and strategies is mandatory.

Di Capua et al. (2017).
Peppoloni & Di Capua (2016).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

1.6. The protégé effect

Description

The protégé effect has been observed from 2007 in a summer scholars institute to introduce urban underrepresented minority (URM) high school students to applied geosciences at Rutgers University in Newark, New Jersey.

The URM teaching assistants shows felt responsible to serve as positive role models for the URM high school students, and then became committed to succeed in college and in careers in the geosciences. This resulted in a higher retention of undergraduate URM geoscience majors who served as teaching assistants in the institute and a more successful recruitment of URM college students to the geoscience program. From 2010, this led to a 50% increase of URM students in the department and a two-fold increase in their enrollment.

The camaraderie of the teaching assistants formed the basis of a self-supporting learning/social community of URM geoscience majors within the Department of Earth and Environmental Sciences at Rutgers University that attracted URM students from other majors. The protégé effect is a potential best practice for increasing diversity in the geosciences, especially in urban areas.

Lessons learned for ENGIE:

It can be useful to involve girls already studying geosciences and geo-engineering at University in ENGIE activities, as mentors to younger school girls.

Gates (2019).

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1.7. Geoscience in the Anthropocene

Description

Geologists still fail to reach the vast majority of students with geoscience education at the high school and college levels. The cognitive science and pedagogical research that has developed in the last 50 years validates best practice and supports broad reform in geoscience education.

The past 15 years have seen a widespread rise at the undergraduate level in interest in effective teaching, along with increased use of active learning strategies, research-based best practices, real-world data, and authentic assessment.

Lessons learned for ENGIE:

The need to involve students in real scientific work in the framework of ENGIE dissemination activities is evident. As stated in the paper, students best learn when they apply what they know to novel and complex situations and when they must explain their knowledge to someone else.

Tewksbury et al (2013).

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1.8. Inquiry and Tenets of Multicultural Education

Description

A case study of an urban, dual-language middle school classroom is presented in which the teacher used an alternative instructional approach, involving her students in an authentic geological investigation with fossils. In this instructional setting, the teacher successfully engaged her English-language learning students from Latino backgrounds in science learning through inquiry, instructionally congruent science teaching strategies, and explicit instruction in Nature of Science (NOS, i.e. what Science is, how it operates and how scientists work).

The used hands-on practices provide a compelling example of how science instruction can be carried out in a way that makes science accessible despite linguistic differences, resulting in students' interest and engagement in activities.

Lessons learned for ENGIE:

Another positive example on how hand-on activities can increase the interest of students and also allow the breaking of linguistic/cultural barriers.

Meyer et al. (2012).

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1.9. Environmental Education

Description

The interactions between a recognized environmental residential camp and students and teachers from six participating schools were researched using grounded theory methodology, in order to gain a better understanding of effective Environmental Education (EE). Data generated included lesson plans, survey responses, and interviews.

Students identified wilderness and geology related activities as the activities they wanted to experience more; they also identified developing curiosity and a sense of discovery as the most meaningful. Whereas most student-identified meaningful experiences aligned with the center's curricular objectives within the optional units, categories emerged that were not explicitly targeted in the unit activities but were embedded throughout the curriculum in sustainable practices, data collection, and reflections.

Lessons learned for ENGIE:

The direct exposure to open environments through filed trips and outdoor activities is greatly appreciated and should be made a must for ENGIE dissemination actions.

Walker et al. (2017).

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1.10. Gender Gap in Science interdisciplinary project

Description

"Gender Gap in Science" was a three-year project (2017–2019) funded by the International Science Council and involving eleven scientific partner organizations. Its main goal was to investigate the gender gap in STEM, globally and across disciplines. A global survey of scientists with more than 32,000 responses was initially performed, then an investigation of the effect of gender in millions of scientific publications was promoted and, finally, best practices to encourage girls and young women to enter STEM fields were compiled.

Lists of recommendations were provided, addressing instructors and parents, but also local organizations and Scientific Unions. Recommendations for instructors and parents include: 1) avoid gender stereotyping and unconscious gender biases; 2) avoid books and media that reinforce gender gaps; 3) develop gender awareness in classroom and 4) encourage relevant single-sex activities to raise girls' self-confidence and possibilities for expressing themselves.

The project surveyed many initiatives that have been developed to enhance the participation of girls and women in STEM fields, but found out that it was not always clear which of them worked and why, thus strongly advising the need to measure impacts. It also suggested to take the SAGA Science, Technology, and Innovation Gender Objectives List (STI GOL), developed by UNESCO, as an initial conceptual scheme to capture dimensions of "good practice" (see page 16 for the specific entry in this database). Nevertheless, the specific strategies that were most commonly observed in successful initiatives aimed at: 1) promoting STEM related vocations to girls and women in primary, secondary, and higher education; and 3) promoting mentoring of young girls by higher education or STEM professionals.

Lessons learned for ENGIE:

Recommendations provided for instructors and parents should be strictly followed also during awareness increasing activities that are the "core" actions of the ENGIE project. The need to measure impacts should be one of the basic concerns of ENGIE activities: satisfaction questionnaires should be carefully defined and handled in order to ensure the project's impact on societal change and future generations of girls.

Gender Gap in Science (2020).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

1.11. SAGA – STI GOL

Description

The STEM and Gender Advancement (SAGA) is a global UNESCO project supported by the Government of Sweden through the Swedish International Development Cooperation Agency (Sida).

The general objective of SAGA is to contribute to reducing the gender gap in science, technology, engineering and mathematics (STEM) fields in all countries at all levels of education and research. Furthermore, SAGA aims to analyze how policies affect the gender balance in STEM, undertake inventories of science, technology and innovation (STI) gender equality policies, develop new and better indicators to provide tools for evidence-based policy-making, build capacity in Member States for data collection on gender in STEM, and prepare methodological documents to support the collection of statistics.

The Science, Technology and Innovation Gender Objectives List (STI GOL) is a tool for classifying STI policies and indicators, developed in the framework of SAGA. Entries of this list are as follows:

1. Change perceptions, attitudes, behaviors, social norms and stereotypes towards women in STEM;
2. Engage girls and young women in STEM primary and secondary education through vocations' promotion, teacher training, and hands-on training and experiment activities;
3. Attraction, access to, and retention of women in STEM higher education;
4. Gender equality in career progression;
5. Promote gender dimension in research content, practice, and agenda;
6. Promote gender equality in STEM-related policy-making;
7. Promote gender equality in entrepreneurship activities.

Lessons learned for ENGIE:

ENGIE perfectly fits in SAGA STI_GOL entry # 2 in which the engagement of girls and young women in STEM primary and secondary education is attained through vocations' promotion, teacher training, and hands-on training and experiment activities.

UNESCO (2016).

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1.12. Integrated STEM education

Description

As integrated STEM education has positive effects on students' achievement in STEM subjects, their attitudes and interest in school, and their motivation to learn, the aim of the study of Thibaut et al. (2018) was to find variables that can explain variation in teachers' instructional practices in integrated STEM.

"Integrated STEM education is an instructional approach in which students participate in engineering design and/or research and experience meaningful learning through integration and application of mathematics, technology and/or science. Five distinctive but related key principles for integrated STEM were discerned by different authors: integration of STEM content, problem-centered learning, inquiry-based learning, design-based learning and cooperative learning. Prior research has shown that two groups of variables can affect the implementation of an educational program: teacher-level characteristics, such as attitudes, and contextual characteristics of the teaching setting. Therefore, the effects of these two groups on the teaching of integrated STEM were examined."

Data were collected as part of a larger study investigating STEM education in Flanders. "An online questionnaire was administered to 595 secondary (K6-K12) schools between January and March 2017. For this study, all teachers who indicated that they were involved in teaching integrated STEM were selected. This led to a sample of the study consisting of 244 in-service teachers from 121 schools."

According to their results, "for each category, teachers' attitudes were found to positively affect their instructional practices. Moreover, different aspects of school context were found that influence teachers' instructional practices, either directly or indirectly."

Lessons learned for ENGIE:

Integrated STEM education is a good teaching method, and its key principles can also be applied during the lectures and/or programs of ENGIE project.

Thibaut et al. (2018).

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1.13. Inquiry-based STEM education

Description

The aim of Inquiry-based Educational Designs (IED) is to effectively engage students in Inquiry tasks, usually by combining digital tools such as online labs and modeling tools. This is a difficult task for teachers, "since it involves manually assessing the type/level of tool-supported guidance to be provided and potentially refining these to meet guidance needs of individual students" (Sergis et al., 2019).

In the research of Sergis et al. (2019), an evaluation protocol was established based on the educational data and IED collected in the context of the major European project "Global Online Science Labs for Inquiry Learning at School" (Go-Lab) (http://www.go-labproject.eu), which employed the Graasp digital learning environment for collecting students' educational data from the delivery of IED. In their case study, they "target to facilitate teachers in the process of reflection and (re)design of their IED. To meet this need, the core standpoint is that educational analytics methods should move beyond tracking and reporting student activity and performance for the purpose of individual student scaffolding during the learning process (primary focus of existing Learning Analytics approaches). Instead, these methods need to support teachers with insights on how to systematically improve their teaching practice and provide more tailored and effective learning experiences to the students. Such insights should support teachers in analyzing as well as evaluating their educational designs, based on data-driven insights". They introduced a two-layer evaluation protocol, aiming to assess the capacity of the proposed TLA ("Teaching and Learning" Analytics) method/tool to analyze existing IED and, also, to robustly validate whether and how the provided insights of the tool offer significant indicators influencing students' activity. The results showcase that the proposed TLA method and tool generate insights that are significantly correlated with diverse aspects of students' activity during the Inquiry learning process. Therefore, it is argued that the proposed TLA tool could be used to support teacher inquiries aiming to improve students' learning experiences through the provision of appropriate and, potentially, personalized guidance."

Lessons learned for ENGIE:

The Inquiry-based Educational Designs (IED) method also can be used for popularizing geosciences and inviting more young people to participate on the programs of ENGIE.

Sergis et al. (2019).

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2. Programs and projects for schools and the general public

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.1. UCAR SOARS

Description

The Significant Opportunities in Atmospheric Research and Science (SOARS) Program combines multiple summer research experiences with intensive, multidimensional mentoring and a robust learning community to help undergraduate students complete college and make successful transitions into graduate school in the Atmospheric and related sciences. During 10 years (1996-2006) SOARS has engaged historically underrepresented protégé students (African Americans, Natives, Latinos, females, LGBTs, students with disabilities and first-generation college students) in authentic research experiences, i.e. 10-weeks summer program within which they conducted research. SOARS has been widely recognized through formal and informal assessments as a highly successful program. Indeed, SOARS satisfied the eight design principles and the pervasive need that were distilled from the Building Engineering and Science Talent (BEST) examination of over 100 programs with documented success in recruiting and retaining minority students in sciences, technology, engineering and mathematics. The design principles are: 1) Institutional leadership; 2) Targeted recruitment; 3) Engaged faculty; 4) Personal attention; 5) Peer Support; 6) Enriched Research experience; 7) Bridging to the next level, and 8) Continuous evaluation. The pervasive need is a comprehensive financial support.

Lessons learned for ENGIE:

ENGIE could fit well into BEST design principles 2, 5, 6, and 7 and all effort should be made to fulfill them in project’s actions.

Pandya et al. (2007).

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2.2. The Texas Earth and Space Science Revolution

Description

The Texas Earth and Space Science (TXESS) Revolution was a 5-year teacher-professional development project that aimed to increase teachers' content knowledge in Earth science for 12th-graders.

The project was designed around six principles that proved to be critical for its success: (1) model best practices in workshop presentations, (2) use authentic Earth science data and cybertechnology to teach up-to-date content, (3) provide ongoing training to cohorts of learners over a 2-year period, (4) involve geoscience consortia and programs that can provide proven content for classrooms, (5) use ongoing evaluations to guide future workshops, and (6) provide opportunities for leadership development through participation in research and curriculum development projects. The project served 177 science teachers and directly impacted more than 29,000 students.

Lessons learned for ENGIE:

The train-the-trainer approach of which TXESS is an example is a very effective way to address large number of students through the instruction of their teachers. ENGIE dissemination activities should consider also this approach. Actually, Task 2.5 "Methodology course to science teachers" is planned not only to advance the gender sensitivity among the teachers, but also to introduce them to new ideas for making geosciences and engineering more interesting.

Ellins et al. (2013).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.3. Building capacity at HBCUs and MSIs

Description

In the US, federally funded programs are developed to increase diversity in the geosciences in minority-serving institutions (MSIs) and historically black universities and colleges (HBCUs). Outcomes, successes, and challenges of two such programs at the North Carolina Agricultural and Technical State University (NCAT) are described, with emphasis on lessons learned and best practices and strategies that could be applied to build and sustain geosciences programs at HBCUs and MSIs. Both were designed to address the severe underrepresentation of minorities in the geosciences by building infrastructure and human capacity.

The NOAA-Educational Partnership Program with MSIs (EPP) funded Interdisciplinary Scientific Environmental Technology Cooperative Science Center (ISETCSC) from 2006 to 2011 at six academic partner institutions. The objectives were to: 1) expand university educational program; 2) leverage ongoing K12 education program; 3) expand exchanges between NOAA and academic partner and 4) develop degree programs. They were attained through: 1) mentoring (one-on-one guidance); 2) engaging students in key academic experience in groups; 3) peer learning strategies with role models and 4) active learning and field studies. Finally, students were trained to translate research results to non-specialists with the collaboration with laboratories, industries and universities. Feedback surveys were conducted to measure the success of the program.

The NSF funded Partnership for International Research and Education (PIRE) at NCAT from 2005 to 2009. The PIRE program provided: 1) support for a teaching postdoc that enabled offering introductory geophysics courses at NCAT; 2) funding for K–12 teachers' workshops in geophysics, and 3) funding for students' participation in summer international field research experience.

The NOAA-EPP-ISETCSC proved to be more successful because more funds were available. Indeed, one -time funding as for NSF-PIRE might not be enough to grow self-sustaining programs.

Lessons learned for ENGIE:

Strategies developed by these programs (i.e. mentoring, field and lab experience in groups, role models for peer learning) can be put into practice also in ENGIE as girls are indeed a minority in specific STEM areas.

Bililign (2019).

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2.4. Research Experience for Undergraduate

Description

The inclusive and supportive Research Experience for Undergraduates (REU) program introduced diverse students to the Department of Atmospheric Science at Colorado State University (CSU)SU and supported faculty in working with them.

Best practices for recruiting and retaining diverse students included: 1) an early exposure to research; 2) mentoring, and 3) supportive campus environments

Lessons learned for ENGIE:

The exposure to research and research practices might be applied also to school girls involved in the ENGIE project.

Burt et al. (2015).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.5. The Orion model

Description

The field trip has long been recognized as a teaching tool in education, particularly in geology and biology, but teachers seldom use outdoor activities as an integral part of their curricula for logistic reasons, lack of adequate teaching materials and unfamiliarity with the outdoor as a learning environment.

The purpose of the work by Orion (1993) was to provide a practical model for planning and implementing a field trip. For a start, any field trip should comply with basic assumptions: 1) the main instructional strategy of field trips should be hands-on experiences; 2) activities for students should involve observation, tactile experience, identification, measurement and comparison, to create a process-oriented approach; 3) students should be prepared prior to the field trip, in order to reduce the novelty space associated with this experience; 4) the field trip should come as an integration to a school curriculum unit. The proposed multistage model is defined by the following steps:

1. Organization of curriculum concepts from concrete to abstract, and choice of the study area;
2. Educational mapping of the study area;
3. Matching curriculum concepts and the field concept inventory;
4. Planning the route;
5. Development of teaching and learning aids.

Three learning cycles should be taken into account: 1) the preparatory unit (i.e. a relatively short presentation of settings and scientific topics unit to reduce the novelty space; 2) the field trip, and 3) the summary unit where quizzes and questionnaires are used to verify the knowledge acquired and the success of the activity.

Fieldworks organized in Portugal in accordance with Orion's model were effective in helping students to achieve the knowledge required to fulfill Natural Science syllabus learning objectives. It is suggested that this approach is assumed as an integral part of formal school science curricula.

Lessons learned for ENGIE:

Field activities and hand-on experiences proposed to students should be arranged accordingly to this model.

Orion (1993).
Esteves et al. (2013, 2015).
Lima et al. (2009).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.6. Good practice guide for field trips

Description

Field trip practices in geosciences work towards the pedagogical target of promoting confrontation with geological objects. This contribution identifies three kinds of interactivity with the field trip study area : 1) a “Heart on” or emotional interactivity that emphasizes connection with the sensitive facet; 2) a “Hands on” or manual interactivity that stimulates active behaviors and is addressed specifically to school-boys and girls (for example, “Fossicking”, geological club, and geotrails), and 3) a “Minds on” or mental interactivity that develops knowledge building and acquisition.

Lessons learned for ENGIE:

Field trip developed for ENGIE activities should consider all three kinds of interactivity

Cayla et al. (2010).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.7. Urban Field Geology

Description

Field trips are recommended by the National Science Education Standards, but seldom used because of a number of reasons: 1) lack of planning time, preparation, resources, insurances, and teacher commitment; 2) excessively large classes that create problems of disciplines and learning effectiveness, and 3) difficulties in tying isolated field trips to curricular goals.

Summer institutes for urban teachers in Milwaukee in the late 1990s centered on several Lake Michigan beaches within the bounds of school districts. The good field trip teaching practices of "Teaming-Up" (i.e. each component of the working group is given a specific task), reducing novelty space, and pre- and post-field trip activities were used. In addition, 3-weeks workshops were offered to teachers with lessons and instructional video on web-based virtual trips. Results showed that teachers have increased their personal belief in their ability to teach earth science more effectively. Professional networks are considered an effective strategy for enhancing the professional learning of teachers.

Lessons learned for ENGIE:

Best practices used in these activities should be used also in ENGIE. The involvement of EFG professional network is further evidenced.

Kean & Enochs (2001).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.8. Personal assistants in field trips

Description

In 2014, the Geological Society of America sponsored an Accessible Field Trip, designed to demonstrate best practices in accommodating a wide variety of participants with disabilities during a field experience. During the trip, an aide was deployed to assist two student participants with sensory disabilities, one with low vision and the other with deafness. The lived experiences of the participants and the assistant describe the efficacy of personal assistants in field study as they facilitate a positive perception of the student with a disability within the full group.

Key skills of the personal assistant include awareness of spatial placement, communication, and flexibility. Three fundamental recommendations are presented for the effective use of personal assistants. These skills are preferable also for trip leaders/planners as they need to become familiar with student's personal and cultural background.

Lessons learned for ENGIE:

Personal assistants and personal assistant's skills must be considered when planning ENGIE dissemination activities, especially when field trips are programmed. In general, greater inclusiveness should be provided for every initiatives aimed at rising the interest for science, particularly for geoscience.

Hendricks et al. (2017).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.9 Designing Effective Field Learning Experiences

Description

Field instructions have traditionally been at the core of the geoscience curriculum. It is a pedagogically exciting approach to introduce students to geology in an engaging, hands-on way. Field experiences have also been used for recruitment and retention of students to departments and as portals to geoscience careers. Similar to designing any teaching activity or course, designing field trips requires attention to a number of important issues, included in the points below:

1. Define learning outcome goals.
2. Assessing student learning in the field.
3. Preparing to go in the field.
4. Behavior during the field trip.

Lessons learned for ENGIE:

Every project participant should prepare with care and attention field trip activities to be performed as ENGIE dissemination actions.

Mogk & Whitmeyer (2012).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.10. Piovono idee! & Co

Description

Piovono idee! (Cloudy with a chance of ideas!) is the participative scientific dissemination project of the Istituto Nazionale di Geofisica e Vulcanologia (INGV) on environmental education designed for students of the last two grades of primary school and the first grade of middle school. It was selected as a continuity project for pupils going from primary to middle school for the educational year 2017/2018.

The aim was to promote scientific culture in primary and middle schools, emphasizing the importance of Science in everyday life in order to favor the sustainable development of Society. The project was developed as an interactive learning experience on hydrogeological risk and climate change and followed the dramatic experience of floods experienced by students in October 2011 that devastated wide territories of the famous Cinque Terre in the Liguria Region (Italy).

Hands-on experiments, visits to laboratories, and interactive exhibits were part of to the project's learning pathway. Peer education was strongly encouraged with students from middle schools acting as tutors of pupils from primary schools.

The project aimed also at giving schools a support for the development of a curriculum on environmental education. The key approach involved the fusion of scientific knowledge with emotional intelligence, through hands-on experiences (learning by doing) and role-playing games (learning by playing).

Other similar dissemination projects by INGV are: 1) ERiNAT (Education to Natural Risk); 2) A 300 M.Y. Long Journey and Natural Disasters (on volcanoes); 3) Scientist as a Game (Science Theatre).

Lessons learned for ENGIE:

Hands-on activities and any other activity in general should be tailored in accordance to everyday life experiences of students (i.e. what really affects them and matters to them), in order to promote not only scientific knowledge but the development of emotional connections.

Musacchio & Pino (2014).
Piangiamore & Musacchio (2019).
Piangiamore et al. (2014, 2015).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.11. Palaeontology at School

Description

A series of actions and projects between the University of Catania and high schools in Sicily and Lombardy were promoted from 2007 to 2019 to raise interest in geosciences by high school students. They were all based on a collaborative school-university effort, to consolidate knowledge on geoscience disciplines through practical experiences. Proposed actions contributed to build teacher's practical and personal experience. Time scheduling was generally within school hours and activities were aimed principally at 18/19 years old with the occasional participation of 15-7 years old.

The key tools of the projects were: 1) seminars (with written questionnaires before and after to evaluate the effectiveness of active learning); 2) laboratories in small groups and through cooperative learning; 3) ludic-didactic activities, such as games and quizzes under an award competition; 4) guided visits; 5) active participation to the work of the palaeontological museum in the framework of school curricula needs (Alternanza Scuola-Lavoro); 6) Field trips addressed to teachers to consolidate their knowledge; 7) geoevents and workshops. The most appreciated activities were those including active learning strategies, such as interactive work and hands-on experiments in laboratory. Partially as a result of these projects, the matriculations at the Geological Faculty of the University of Catania increased from 68 in 2016/2017 to 90 in 2018/2019.

Lessons learned for ENGIE:

ENGIE actions towards primary and secondary school students should favor active learning strategies in laboratories and in the field.

Sanfilippo et al. (2019).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.12. Geomobil

Description

The “Geomobil” is a mobile education and training facility which tackles playful capacity building for geological hazards in schools. It is one example of preparedness and awareness raising, managed by the Department for Mining and Energy of Aceh Province (Indonesia).

The Geomobil regularly conducts visits to elementary schools throughout the province accompanied by professionals. Using theoretical and practical learning elements, pupils are enabled to understand the existing geological hazards and train how to safeguard themselves. This best practice example from Indonesian governmental institution shows how important effective information and training concepts are to build resilience within the society.

Lessons learned for ENGIE:

The need for finding funny and amusing tool kits to describe and train on specific geoscience issues is essential for the success of ENGIE actions in increasing girls’ interest for those subjects.

Mukhlis et al. (2017).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.13. Mock outcrops

Description

Student learning in the geosciences is enhanced by exposure to geology "in the field," where students put knowledge into practice to solve problems and make interpretations. When this is made hard for a series of reason (economical and practical), institutions may transform portions of their campuses into geological learning environments suitable for instruction at all levels by constructing mock outcrops.

At the Central Michigan University, a variety of mock outcrops have been constructed from simple groupings of lithologically distinct boulders to a complex "campus geological area" encompassing a variety of igneous, sedimentary, and metamorphic rocks, various artificial unconformities, and simple to complex structural relationships.

Lessons learned for ENGIE:

3D models might be an effective instrument for teaching both indoor and outdoor during ENGIE activities.

Matty (2006).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.14. Use of models at school

Description

The use of models in science teaching is considered fundamental since it enables active learning of science. Indeed, the use of models may help students in the development of a better understanding of scientific content, of inquiry skills and also in the understanding of the nature of models and of the Nature of Science (NOS, i.e. what Science is, how it operates and how scientists work). In addition, they help in perceiving geological processes and forces that are beyond our daily experience. However, they are not much used by science teachers. Consequently, it is important to develop science teachers' views of the nature of science and regarding models, in a way that may contribute to the improvement of their teaching. An intervention program was planned and implemented to prospective science teachers to improve their view of models and the NOS. Feedbacks were evaluated through questionnaires and interviews.

Lessons learned for ENGIE:

The use of models or tool kits for teaching geological processes and concepts should be encouraged during ENGIE dissemination activities.

Torres et al. (2017).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.15. ScienzAperta

Description

ScienzAperta, i.e. Open Science, is an outreach week conceived and promoted by the Laboratorio Didattica e Divulgazione Scientifica of the Istituto Nazionale di Geofisica e Vulcanologia (INGV). Every year ScienzAperta is an opportunity to open to the public and to share with the community the places where research is performed, through events distributed in different times and places, with scientific exhibitions, hands-on laboratories for kids, meetings and seminars with researchers and guided tours to scientific laboratories. All the activities have the common idea to intrigue, interest and stimulate audiences of all ages. Some of these initiatives have been organized jointly with other institutions and research institutes, cross-pollinating disciplines. On the occasion of the 2013 edition, questionnaires have been distributed among adults and children during the Open Day held in INGV Rome headquarters.

Lessons learned for ENGIE:

This initiative is similar to the Researcher's Night that is already included among the ENGIE dissemination actions.

D'Addezio et al. (2014).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.16. Raw Matters Ambassadors at Schools 3.0

Description

Raw MatTERS Ambassadors at Schools 3.0 (RM@Schools) is the Flagship program in the Wider Society Learning segment of EIT RawMaterials. It is an European project promoting an innovative program to make education and careers in raw materials attractive for youngsters.

The challenges on raw materials are divided in four main areas, such as exploration and mining, recycling, substitution of critical materials, and circular economy. All these themes can be well linked to STEM subjects.

An active learning is proposed to schools by RM Ambassadors (experts in some RM-related issues and trained teachers) by involving students in experiments with RM-related hands-on educational kits, in excursions in industries, and in science dissemination activities. In order to transform classes into labs, the consortium created experiments connected to the RM-issues/solutions (Toolkits – available on a e-learning platform https://rmschools.isof.cnr.it/moodle/). The trained students are asked to become Young RM Ambassadors themselves (science communicators) and to create dissemination products focused on issues related to RM. Thus, in this project students are creators of the activities and multipliers of knowledge. Under supervision of the educators, students from the age of 10-19 create their own experiments, serious games (i.e. games with educational elements), and communication materials (i.e. videos, cards, comics, etc.) in English for other teenagers and the wider public.

Local competitions for awarding the best communication products, as well as an annual European Conference with delegates from European schools (students and teachers), are organized annually. In addition, teachers are also trained with the aim that through them the project’s themes will become imbedded in school curricula.

Lessons learned for ENGIE:

The success of the annual international conference for school students organized by RM@Schools could be of inspiration for similar events in ENGIE project. It will give young people (especially girls) an opportunity to present their achievements and boost their self-confidence in the field of science. Similarly, an idea of involving school students in organization of events for the others should be taken under consideration.

https://rmschools.isof.cnr.it/index.html

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.17. Research Language

Description

Research Language (Linguaggio della Ricerca, in Italian) is a project that aims to contribute to the public understanding of science by creating a network between Research and School. The project is the result of a strong collaboration between Italian schools and research centres such as the Italian National Research Council (CNR), the National Institute for Astrophysics (INAF) and National agency for new technologies, energy and sustainable economic development - ENEA.

The project, born in 2003, fosters a tight collaboration between schools (middle and high - school students age 10-19) and scientific community in order to stimulate students' interest towards STEM subjects and research and ultimately engage them as scientific popularisers. This is a national project which is being carried out with success throughout the country. In 2009 the project was selected as the national most innovative initiative for the popularization of science in schools. In 2013 it represented a case-study within the European project "Science Teaching European Network for Creativity and Innovation in Learning (STENCIL)". In 2017 it was funded by the Italian Ministry of Education, University and Research (MIUR) and at the moment it involves an Italian Network composed of 25 Institutes distributed in 10 Italian regions. A working scheme was developed over the sixteen years of the project's duration. It consists of several phases:

1) Presentations and lectures hold by researchers for students;
2) Laboratory exercises or visits to research laboratories;
3) Based on knowledge gained during phases 1 and 2, students are requested to be themselves popularisers by producing communication material related to what they earned during the lecture and laboratory activities;
4) School competition and annual conference. The best materials provided by students, in terms of scientific and linguistic accuracy and communication appealing, are awarded during an annual conference.

Lessons learned for ENGIE:

A strong national network between researchers, teachers, and other stakeholders is a key for the long-lasting legacy of educational projects in school systems when combined with clear and repetitive plans of action.

https://ldr-network.bo.cnr.it/index.html.

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.18. Virtual Field Environments

Description

Virtual field environments (VFEs) based on actual field sites are being used in professional development programs to familiarize teachers with field sites and give them the opportunity to practice investigative fieldwork, thus helping them make better use of limited time on field. In other cases, the construction of VFEs provides a catalyst for actual fieldwork, and teacher workshop participants author VFEs that they can use with their own students. Virtual fieldwork development also improves technological skills relevant for the teaching of Earth system science.

Lessons learned for ENGIE:

The use of VFEs can be envisioned for ENGIE dissemination activities, especially if social distancing will be requested also in the next years.

Granshaw & Duggan-Haas (2012).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.19. GIS for education

Description

GIS-project ''World experience in site investigation and construction under different engineering-geological conditions'' includes numerous data on engineering objects (engineering structures), and contains more than 20 layers divided into three blocks. Base layers include geographical and geological maps of the world, forming the first block of information. Map of engineering-geological structures of the Earth is the second block, it consists of 8 layers. The intersection of these layers gives taxonomic units of engineering-geological zoning of the four hierarchical levels. Engineering objects (buildings, dams, reservoirs, bridges, tunnels, etc.) form the third block. Attributive table contains data on every object and on its engineering-geological conditions: relief, composition and properties of foundation rocks, groundwater, geological processes, the difficulties that arise upon construction, as well as the source data. This GIS-project can be used as a reference database and in educational activity

Lessons learned for ENGIE:

The use of GIS programs for exploring virtual landscapes can be envisioned for ENGIE dissemination activities, especially if social distancing will be requested also in the next years.

Averkina et al. (2014).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.20. Augmented reality in STEM education

Description

Augmented reality (AR) is a 3D technology that enhances the user's sensory perception of the real world with a contextual layer of information (Azuma, 1997). Ibáñez and Delgado-Kloos (2018) reviewed and synthesized 28 publications from 2010 to 2017 in order to collect and analyze the possibilities of applications the AR technology in STEM education.

“Three categories of AR-based learning applications for STEM emerged from the literature: exploration, simulation and, to a lesser extent, game-based applications.

The results show that the reviewed AR-based learning applications for STEM are evenly distributed among physics, mathematics and life sciences topics. Most of the interventions related to life sciences topics took place in out-of-class settings using location-based AR-features, whereas physics and mathematics interventions usually were made in-class using marker-based or image-based location AR features. Moreover, life sciences topics were mostly deployed using AR-based exploration tools, with inquiry learning activities orchestrated by teachers, while physics and mathematics interventions were generally devoted to exploration or simulation, with an emphasis on the understanding of STEM phenomena.

Evaluations made in quantitative studies suggest that augmented reality technology fosters positive affective states of students, such as motivation, engagement, and attitudes toward STEM subjects, that have proved to be effective in promoting learning benefits; these act through the mediation of usability on learning outcomes.”

Lessons learned for ENGIE:

AR is quite a new technology and its application in STEM education is proved useful. It should be investigated how this technology could be used in ENGIE to help bring geoscientific phenomena closer to students.

Azuma (1997).
Ibáñez & Delgado-Kloos (2018).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.21. HOME I/O

Description

Riera et al. (2016) in their study deal with the result of a 3-year R&D project called "DOMUS" (2011-2014) partially founded by the French Ministry of National Education to create a virtual house: HOME I/O.

"The idea has been to bring a virtual house into the class room, usable from middle schools to universities, adapted to learners (Y generation) and teachers and suitable for control and STEM education. HOME I/O has been designed by applying a systemic approach of education. With this innovative pedagogical tool, the possibilities of pedagogical scenarios in control and STEM education depend only on teachers' imagination.

HOME I/O is real time simulation software of a smart house and its surrounding environment, designed to cover a wide range of curriculum targets within Control, Science, Technology, Engineering and Math, from middle schools to universities. This virtual house, like a video game in first person, thus becomes a place of discovery and experimentation for STEM fields, that it is not possible for obvious reasons of cost, space and feasibility of owning in schools. Hence, virtual does not just replace, but rather complements the real.

HOME I/O offers a unique learning experience with immersive and motivating hands-on activities for several educational areas. It is a great tool for teachers to explore and develop engaging activities in a project-based learning environment suitable for STEM, where students analyze situations, search for answers and provide solutions. With HOME I/O, control and STEM education becomes a game where the teacher is the game master. An experimental stage with 50 teachers from middle and high schools has shown that this kind of tool changes the way to teach and requires new training for teachers."

Lessons learned for ENGIE:

Similar tools (e.g. virtual reality headsets) with innovative simulation software also can bring closer young students to the field of geosciences.

Riera et al. (2016).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.22. Improvement in mathematics education and achievement

Description

A case study was conducted at five high schools located in Las Palmas (Gran Canaria, Spain), during December of 2012 and at the end of the school year, approximately 6 months later to identify factors that support and motivate students to learn and achieve in math (León et al., 2015). In their test, 1412 secondary students participated (670 males, 681 females, 61 gender not reported; mean age=14 years).

The authors established a model where autonomy would predict autonomous motivation, which in turn, has a positive effect on effort regulation and deep-processing, and both variables would predict math achievement. Their results confirmed all hypothesized paths, except deep-processing unexpectedly did not predict math achievement.

“Findings suggest that when students feel that their schoolwork is purposeful and interesting, and that the classroom environment and teachers are responsive and supportive, they will be autonomously motivated to engage in self-regulated learning. Autonomous motivation propels students to engage in deep-processing of information and to persist and exert effort in their studies even when the school subject or studying becomes boring or taxing. Self-regulation of effort ultimately results in enhanced mathematics achievement.”

Lessons learned for ENGIE:

This approach (i.e. purposeful, interesting and supportive education to achieve autonomous motivation of the students) is also applicable for each STEM subject, as well as for the ENGIE project.

León et al. (2015).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.23. Sample Lesson Plan in STEM Education

Description

The main goal of the case study of Ceylan & Ozdilek (2015) is to present a sample lesson plan on acids and bases based on STEM education for Turkish Science Education System. Single group pre-test/post-test design was used in the fall semester of the academic year 2013-2014. 12 different 8th grade students (4 boys and 8 girls) were chosen for the population of their study.

In teaching the subject to the students, the sample lesson plan based on STEM approach was used in compliance with 5E learning cycle model: Engagement Phase (the aim is to determine the students' prior knowledge and motivate them to engage in learning the topic), Exploration Phase (use of science process skills such as observing, measuring, classifying, inferring, predicting, communicating, defining operationally and collecting data during hands-on activities), Explanation Phase (the teacher explains the concept in accordance with students' answers that they acquired as consequences of their previous experiences), Elaboration Phase (students use their new knowledge in different situations), Evaluation phase (an achievement test that assesses the students' learning outcomes).

"It is found that students had inadequate knowledge about acids and bases before the study, but they managed to gain the learning outcomes in sufficient level after the implementation." They also suggest that "additional engineering activities should be applied using project-based instructions with more interested students".

Lessons learned for ENGIE:

Based on the above-mentioned case study, the 5E learning cycle model is effective to teach STEM, and an example to follow in every lesson and/or program organized through ENGIE project to enthuse young children toward geosciences.

Ceylan & Ozdilek (2015).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.24. FabLab activities for STEM education

Description

Through two case studies, the article of Dreessen & Schepers (2019) described how to engage non-expert users – more specifically, children of 6–16 years old – in FabLab Genk in relation to STEM education. FabLabs are open workplaces (currently 1251 worldwide), aimed to explore the implications and applications of personal fabrication. They are community spaces that offer public, shared access to high-end manufacturing equipment, and also integrated in (after) school programs.

The first case was the 'Wa Make?' (local slang for 'how are you?'), which entailed a series of workshops organized within a school context, wherein limited effort was put into backstage activities when organizing the trajectory. The other case was the 'Making Things!', which embedded STEM workshops in long(er)-term trajectories, departing from the children's interest and focusing on backstage activities, children get beyond '30 min' introductory activities.

"If this is the case ['Making Things!'], they start experimenting and are better able to open up to learning. Therefore, we advocate for thoroughly reflecting upon how to engage non-expert users, such as children, in FabLabs for STEM educational purposes and putting time and effort in the backstage regions. We believe this allows for considering FabLabs as more than merely technical infrastructures."

Lessons learned for ENGIE:

These (after) school programs are good initiatives to draw the children's attention on STEM education. Such programs related to geosciences are also welcomed in ENGIE.

Dreessen & Schepers (2019).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.25. Earth Science Festival

Description

The Earth Science Festival (Földtudományos forgatag) is organized every November in the Hungarian Natural History Museum (Budapest, Hungary). Many exhibitors show up in the 2 days long event such as museums, universities, national parks, governmental and private companies, which have connections to Earth and environmental science. Everybody presents their work and profile to the public: from young children to seniors. The participants are mainly school groups and families with children.

Lessons learned for ENGIE:

People (especially young generations) can be motivated and their attention captured with interactive presentations. They will understand how Science and Research work and their interest will increase if they get to know how both are related to their life, and what kind of effect they have.

https://foldtan.hu/hu/forgatag2019

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.26. Collectible Past

Description

“The Mineral of the Year” and “The Fossil of the Year” programs are managed by the Society of the Hungarian Geologists. The aim of this program is to bring closer the nature and the geology to the public.

Every year a mineral and a fossil are chosen by public voting. Many events and projects connect to this program:

- lectures, articles
- field trips: light hikings, to present the typical habitats (collection opportunity, which makes it tangible)
- drawing competition (only for children)
- traveling exhibition: some pieces are exhibited in different schools

Lessons learned for ENGIE:

The creative tasks can motivate the young generation (drawing competition). If people experience something, they could become more open-minded.

http://evosmaradvanya.hu/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.27. Geotop Days

Description

The “Geotop Days” is a Hungarian field trip-based hiking program. Trip leaders are always qualified geologists or geographers, who are experts of the visited area and can easily introduce the geologic-, historic- and cultural background of the place to the public.

Often the programs are held in parallel to each other and they are held contemporary in many places throughout the country.

Lessons learned for ENGIE:

Community programs, where the whole family could participate, are very attractive. Thus, within the ENGIE project, similar programs can invite young people to participate in the ENGIE’s activities.

http://akovekmeselnek.hu/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.28. ENABLE-BiH

Description

ENABLE-BiH – Improving primary learning and education in Bosnia and Herzegovina is a project which has been implemented since 2016 with the support of the United States Agency for International Development (USAID) Save the Children. It seeks to achieve positive changes by introducing the STEM concept in primary and secondary education and enable students to acquire the knowledge and skills that they will need for their employment in the future. Establishing cooperation with the business sector enables children to see and experience the business world at an early stage of their schooling and to better understand the purpose of learning and the applicability of knowledge that they acquire in school. STEM teaching encourages students to develop key competencies and skills to participate in the knowledge economy, not only as workers, but also as job creators in the future. The ENABLE BiH project developed cooperation between schools and the business sector, and the first step is cooperation with the Bit Alliance Association, an umbrella organization that brings together the most successful IT companies in BiH.

Lessons learned for ENGIE:

This project shows the benefit of cooperation between primary and secondary school students and potential future employers from the business sector. The communication with accomplished professionals gives the students insight with respect to detailed "first hand" job descriptions, as well as set of skills needed to perform the given activities.

http://enablebih.org/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

2.29. Learning Coding in Primary School

Description

Since programming courses in Montenegro are rare and mostly held in the capital, the Internet Society Montenegro Chapter organized a CodeWeek Java Programming. Their main goal is to strengthen the community and encourage others to involve and organize courses in their small towns. Their target group involve students of 7^{th}, 8^{th}, and 9^{th} grades. Children of this age speak English well enough to understand the Java programming environment, and they are at age when they decide what to study next. It is a great advantage if this decision is made early on, whether they decide to go for programming or not. They promoted the course on national TV stations, online portals, on their website, and Facebook account. Two groups of 17 students and two teachers for each group met twice a week for two hours. They plan to make these courses on regular basis and maybe longer than a month.

Lessons learned for ENGIE:

The project had a great promotional campaign and courses were advertised through the multiple platforms – TV, portals, website and Facebook which definitely helped in gathering of two groups with seventeen students in each group. ENGIE project can learn about ways of promoting project to targeted group of female students.

https://www.internetsociety.org/blog/2018/07/montenegro-learning-coding-in-the-7th-grade/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3. Initiatives/actions aimed at girls and women

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.1. NSF-ADVANCE Program

Description

The National Science Foundation's (NSF) ADVANCE Program aimed at increasing the number of women on the science, technology, engineering, and mathematics (STEM) faculty in the US. Differently from other programs that were designed to help individual women, the signature track of the ADVANCE Program was the "Institutional Transformation" (IT), as awards devoted to removing institutional barriers that negatively affected hiring, retention, and climate for STEM women faculty. From its 2001 initiation through 2011, more than 50 ADVANCE-IT grants have been awarded to institutions across the U.S. to reduce gender segregation by increasing hires and retention.

The key mechanism of most of these awards was included in the Equity Advisory Program that request the appointment of Equity Advisors (EAs) in each school. EAs are respected senior faculty members, selected for their commitment to gender equity, strong interpersonal skills, ability to collaborate with the dean's leadership team, and ability to devote 10 percent of their time to the ADVANCE effort. EAs are intricately involved in the hiring process and work on pay equality, women's advancement, mentoring programs, climate issues, award nominations, and workshops aimed at supporting faculty and graduate students.

The effectiveness of these ADVANCE-IT programs has been evaluated on three outcomes: 1) share of women faculty in campus; 2) share of women as new faculty hires and 3) share of women retention. Results of this evaluation proved that the ADVANCE Program is generally associated with an increase in women faculty representation. Specifically, faculty hiring significantly improved, while faculty retention was less affected.

Lessons learned for ENGIE:

Institutional transformations are beyond the scope of our project, due to the project's typology, its funds and temporal limitations. However, the mentoring role of EA could be of inspiration for ENGIE participants because it implies that only the persistent focus on gender equality in companies that hire geoscientists can result in the increase of female employees' rates.

Nentwich (2010).
Holmes (2015).
Stepan-Norris & Kerrissey (2016).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.2. Global Women's Breakfasts

Description

The IUPAC 2020 Global Women's Breakfast (GWB2020) is a global event that was held on a single day, February 12, 2020, one day after the United Nations Day of Women and Girls in Science, to establish an on-going virtual network where women in the chemical and related sciences could have connected with each other in a meaningful way to support their professional aspirations.

The theme for GWB2020 was "Building bonds to create future leaders" with a focus on leadership development. Women and men from all types of educational and scientific organizations from high schools to universities, to scientific societies, government and industry organizations are welcome to organize breakfast events.

Breakfast events have been small or large, but all breakfast groups were encouraged to reach out and form a new bond with another group or to reconnect with colleagues around the world. A list of events can be found at https://iupac.org/global-womens-breakfast/.

Lessons learned for ENGIE:

The first GWB was held in 2019 with the subject "Empowering Women in Chemistry". Despite the different scientific field (chemistry), the principle of creating bonds among professionals (from universities, scientific societies, government and industry) should inspire similar lower-scale initiatives in ENGIE.

https://iupac.org/global-womens-breakfast/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.3. ASCENT

Description

Atmospheric Science Collaborations and Enriching NeTworks (ASCENT) was a workshop series held in Steamboat Springs, Colorado and designed to bring together female scientists in the field of atmospheric science and related disciplines. The main objective was to retain female junior scientists through the challenges in their research and teaching career paths.

During the workshop, invited successful senior women scientists discussed their career and life paths. They also led seminars on tools, resources, and methods that can help early career scientists to be successful.

Networking was a significant aspect of ASCENT, and many opportunities for both formal and informal interactions among the participants (of both personal and professional nature) were blended in the schedule.

Near the conclusion of each workshop, junior and senior scientists were matched in mentee-mentor ratios of two junior scientists per senior scientist. An external evaluation of the workshop participants concluded that the workshops have been successful in establishing and expanding personal and research-related networks, and that seminars have been useful in creating confidence and sharing resources for such things as preparing promotion and tenure packages, interviewing and negotiating job offers, and writing successful grant proposals.

Lessons learned for ENGIE:

The role model provided by successful senior women at the top of their careers has been proved effective in sustaining female junior colleagues in their struggle during the early stage of their working life. Similar examples will be provided to girls participating to the ENGIE project through the experiences of successful female geoscientists and geo-engineers. In addition, the mentee-mentor interaction can be translated into a researcher-teacher relationship in the framework of the ENGIE project, in order to increase the latter's school curriculum with new topics related to geoscientific issues.

Gannet Hallar et al. (2015).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.4. ESWN

Description

The Earth Science Women's Network (ESWN) aims to promote career development, build community, and facilitate professional collaborations for women across a variety of fields within the geosciences discipline. ESWN is a peer-mentoring network of women, with many early in their careers.

ESWN started in 2002 as an initial group of six early-career women in atmospheric science and has grown to more than 1300 members. ESWN's growth has evolved solely from person-to-person contacts. This disciplinary network has its focus on women at early career stages and was formed and is led by early-career women scientists. ESWN members identify the network as a valuable part of their professional lives and often encourage peers and advisees to join. These features allow the group to assist women in the earth sciences in advancing professionally while connecting them with a community of their peers.

Multiday thematic professional development workshops have been designed to bolster women's scientific career success by developing resources useful to early career geoscientists, initiating mentoring opportunities, identifying strategies for women to overcome barriers to success, and creating community. In addition, short workshops have been developed in concert with professional scientific conferences, giving access to all early-career geoscientists and enhancing useful networking opportunities. By identifying strategies to reduce barriers to professional success for women geoscientists, we aim to promote a culture that will enhance the success of all scientists.

Lessons learned for ENGIE:

Similarly to ASCENT, the confrontation with successful senior women at the top of their careers has been proved effective for female junior colleagues and can be transferred to school girls participating to the ENGIE project

Hastings et al. (2015).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.5. Hypatia project

Description

Hypatia is an EU Horizon 2020 funded project that aims to develop a theoretical framework on gender inclusive STEM education, as well as to provide practical solutions and modules for schools, businesses and science centers and museums across Europe. Their campaign “Expect Everything” extends the “Science it’s a Girl Thing” campaign and inspires teenagers across Europe to reflect the spirit of STEM. The web page is designed to appeal teenagers. However, the page does not promote all careers equally, the emphasize is on technical sciences, since the main menu offers information on following careers: electrical engineer, aerospace engineer, naval architect and mechanical engineer, while other careers are visible only after “check out more dream jobs” button is clicked. Also, there is no “mining engineer” among the possible career choices.

Lessons learned for ENGIE:

The project is structured to include campaign “Expect Everything” which has its separate web page designed to appeal teenagers with all the materials modified to be “teenager friendly”, all descriptions are short, but informative.

http://www.expecteverything.eu/hypatia/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.6. STEM Girls

Description

Petro Kuzmjak Elementary School and Secondary School received special recognition for the STEM Girls project from the Tempus Foundation – Euroguidance Center. The authors of this project are professors Natalija Budinski, Bojana Miljanic, Teresa Katona and Kristina Sabados. The project promotes the activities focused on secondary school graduates with a focus on girls, with aim to bring closer professions in the fields of natural sciences and mathematics. During 2018/2019 meetings with professionals in the field of natural sciences were organized.

Lessons learned for ENGIE:

Similarly to what observed in ASCENT and ESWN, meeting with professionals is a good way to encourage girls into pursuing similar careers.

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.7. Girls can do it

Description

To mark the International Day of the Girls, the Elementary School "Knez Sima Markovic" Barajevo, the Department of Veliki Borak (Serbia) organized a one-day workshop aimed for girls to learn the basics of programming with ZaplyCode - Coding e PixelArt. The event took place on October 11, 2018. The works created during the workshop were donate to participants' friends from the eTwinning project We Meet Animals (from Slovenia, Serbia, Bosnia and Herzegovina, Croatia and Turkey).

Lessons learned for ENGIE:

Raising the interest of young girls for programming in the elementary school is done through the workshop that enables acquiring the new skills and sharing the results with peers.

https://codeweek.eu/view/187036/programiranje-uz-zivotinje-je-lako-devojcice-to-mogu

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.8. Hack # Teen

Description

AFA (the Women's Affirmation Association) and Telekom Serbia, organized Hack # Teen, an event that brought together elementary school students to mark International Girls Day in ICT. The girls and their mentors from Telekom Serbia worked together to develop innovative solutions for motivating girls to choose STEM careers and further develop in science and technology. The event took place on April 20, 2019.

To mark the International Day of Girls in ICT, the Ministry of Trade, Tourism and Telecommunications of the Republic of Serbia and AFA organization planned to organize a competition to create a video game concept – **"Hack # teen 2020"** for schoolgirls aged 11-14. The “hackathon” should have taken place from 21-23 April 2020, but due to COVID-19 was postponed.

Lessons learned for ENGIE:

The event is structured as a competition – hackathon. This format enables young girls aged 11-14 to show their knowledge and creativity and thus to feel more encouraged to further develop/educate in ICT field. A similar approach could be used in ENGIE, i.e. some of the activities could be of competitive form.

https://hackteen.afa.co.rs/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.9. More Girls in STEM

Description

On 21 March 2019 AFA in cooperation with Mercedes Serbia launched a socially responsible initiative aimed at promoting successful women who are active in science and technology in Serbia. "**More Girls in STEM**" (“**više žena u nauci i tehnologiji**”) initiative is designed after Mercedes' global “She's Mercedes” project, which celebrates accomplished and inspirational women, and the project's initiators want to bring together as many engineers as possible and set an example for girls in Serbia for successful professional and personal development in this area.

Lessons learned for ENGIE:

The initiative is strongly supported by the industry and that gives it the additional credibility. Meeting the accomplished female professionals is a good way to set positive examples, to make role-models who young girls can look up to. Also, this helps to show them that not all important positions in the traditionally male industry are occupied by men and that there is enough room for more female experts.

https://www.afa.co.rs/post/afa-i-she-s-mercedes-vi%C5%A1e-%C5%BEena-u-nauci-i-tehnologiji

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.10. Plotina project

Description

The Plotina project (Promoting gender balance and inclusion in research, innovation and training; 2016-2020) starts from the position that the gender issues need to be integral and not supplemental to scientific research cultures and to the knowledge provided by research teaching curricula. It emphasizes the fact that gender balance in research teams is crucial for RPOs (Research Performing Organisations) to maximize their research effectiveness.

Strongly aligned with European Research Area Communication key priority, the aim of PLOTINA is to foster excellence and promote social values in innovation and research by:

- Strengthening women's unused talents
- Ensuring a diversification of views and approaches – considering gender dimensions – in research

The key challenges are defined by two areas of intervention:

- The achievement of systemic changes at the institutional level (human resources)
- The revision of research programs through inclusion of gendered dimensions (gender-aware science)

Lessons learned for ENGIE:

Although the project is not focused on girls but on female researchers, it aims to address the gender inequality and in that sense these types of projects are complementary to projects like ENGIE that promote inclusion of females in traditionally male dominated fields.

https://www.plotina.eu/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.11. #HiddenNoMore: Empowering Women Leaders in STEM

Description

The purpose of the US State Department funded IVLP (International Visitor Leadership Program) is to explore the contribution of women to Science, Technology, Engineering and Mathematics (STEM) through research and development, education and teaching, guidance and policymaking. The 2018 Program promotes women and girls in STEM by breaking barriers in academia, creating inclusive hackathon events, and conducting training in science diplomacy. It was inspired by the movie hit Hidden Factors, which tells the story of a brave black American woman who, in the 1960s contributed with her calculations to launching of the first American astronaut into space. The goal of the program is to empower global leaders in STEM fields who may be "hidden talents" in their communities. Participants explored best practices for the effective employment, education and development of women and other minority groups in STEM and learned how to institutionalize women's opportunities in their countries.

Lessons learned for ENGIE:

The movie Hidden Factors based on a true story helped to promote the importance of women in Apollo missions and in that way established the role models that are easy to identify with. The first computer programmers in the Jet Propulsion Laboratory were women. Only after coding became better paid job, it became male dominated and is today considered to be "male job".

As much as screenings of the mentioned movie in US embassies around the world helped promoting the message of women being capable of doing the computing and programming, the subsequent IVLP was maybe not the best way to help the cause, especially because it encompassed women who were already accomplished professionals in the STEM field and it could be assumed that they were well aware of the message that the Program was spreading.

https://eca.state.gov/highlight/hidden-no-more-heres-how-state-department-empowering-international-women-leaders-stem

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.12. CHANGE

Description

The main aim of CHANGE (CHAlleNging Gender (in)Equality in science and research; 2018-2022) — which is coordinated by IFZ — is to contribute to a structural change towards gender equality in the European Research Area by stimulating institutional cultural change towards gender equal work environments in research performing organisations (RPOs) and fostering the importance of gender dimension inclusive research and innovation programmes in RFOs (research funding organisations). is it to support research performing organisations (RPOs) to design and implement gender equality plans. This will be achieved by involving key actors, called Transfer Agents (TAs), within each organisation who will together with the core consortium partners transmit co-produced gender equality knowledge inside their institutions.

This innovative approach will ensure the promotion and sustainable institutionalisation of the gender equality action plans (GEPs) beyond the project duration. Furthermore, through mutual learning and networking CHANGE will enable partners to become resource centres skilled to provide gender equality knowledge and expertise to other RPOs and RFOs (research funding organisations).

As one of many results, CHANGE will produce policy papers based on this strategic stakeholder involvement including actual policy makers and relevant stakeholders in the policy paper production. With this approach we aim at closing the research-to-action gap, respectively the theory-to-practice gap.

Lessons learned for ENGIE:

The project is not focused on girls but on female researchers and it is focused on achieving gender equality by stimulating institutional cultural change. These types of projects are complementary to projects like ENGIE that promote inclusion of females in traditionally male dominated fields. The gender equilibrium in STEM fields as well as in R & D in general can be achieved through simultaneous activities focused on change of attitude towards female experts and through their greater representation.

https://www.change-h2020.eu/the_project.php

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.13. Girls_Do_Code

Description

From October 2019 to February 2020 Digital School organized a five-month course for girls of the 3rd, 4th, 5th and 6th grades of Ljubljana elementary schools, taking place once a week in the digitally equipped Digital School classrooms. Eight 14-member groups of girls were led by trained and experienced MIE (Microsoft Innovation Educator) certified educators. The curriculum is specifically tailored to the girls.

Activities, among other things, included 3D modeling and printing workshops, electrical engineering basics, VR workshops, mobile application workshops, Java Script ad design, IT department profession presentation… The project was completed with a hackathon (hack + marathon; event, which requires programmer endurance) where girls presented their projects to parents and representatives of partner institutions.

Lessons learned for ENGIE:

The five-month course is organized on a once-a-week basis for altogether more than 100 girls and that structure enabled consistent development of girls' skills in ICT field. The hackathon organized at the end of the course enabled young girls to show the gained knowledge and thus to feel more encouraged to further develop/educate in ICT field.

https://www.digitalschool.si/girls-do-code-projekt-za-dekleta/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.14. CyberGEN Academy

Description

CyberGEN - The Academy for the Education of the Next Generation of Women in Cyber Security is a new and unique educational initiative designed to promote the field of cyber security as the fastest growing field of information technology and to increase the interest of girls in Slovenia for this field. According to the latest data, in the age between 7 and 10, 50% of girls are interested in mathematics, and later, in the age between 11 and 14, this percentage drops to 30% or less. CyberGEN looks at different perspectives on this challenge through an academy that intends to capture girls' attention in cybersecurity. It encourages girls to learn what is cyber security, what they can do as specialists in this field and also meet role models from Slovenia and the wider region, as well as offering a mentoring program for girls who have an interest to further educate in this field.

CyberGEN will bring together girls from 8 cities across Slovenia. The project begins in October and ends in June next year, with monthly activities, meetings and trainings for girls at various locations. The project will involve girls from 10 to 14 years from all 12 Slovenian regions.

Lessons learned for ENGIE:

This educational campaign is focused on 10 to 14 year old girls, because it was identified that girls generally loose interest for STEM around that age, so obviously emphasized effort is needed in order to maintain interest of girls for STEM at that age.

https://dihslovenia.si/cybergen-akademija-kmalu/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.15. Empowering girls to choose ICT @DigiGirlz

Description

DigiGirlz is one of Microsoft's 'community' programs. It aims to invest in STEM education for young women and generate future employees who are ready for the challenges of the global economy. It aims to break tech industry stereotypes and motivate girls to choose a career in ICT. One of the program's activities is Microsoft's DigiGirlz Day, a one-day event designed to improve understanding among high-school girls of what a career in technology looks like.

Since the program's launch in the USA in 2000, DigiGirlz events have gradually spread and are now held at Microsoft locations worldwide. Microsoft Croatia has been organizing DigiGirlz Day since 2013. The program's core aims in Croatia are multiple: to attract more women to STEM studies and raise the number of women working in ICT, but also to break the gender-based stereotypes which generally express male domination in high-tech industries. Throughout the DigiGirlz Day event, diverse activities are organized for high-school girls. In 2016, 90 high-school girls from Varaždin, Koprivnica and Zagreb spent a day at Microsoft, where they attended lectures and workshops organized by Microsoft employees and their partner companies. In 2017, 80 high-school girls from Nova Gradiška, Novska, Ogulin and Karlovac had the same opportunity.

Lessons learned for ENGIE:

The involvement of stakeholders in promoting the STEM careers for young girls is very important, because girls can establish direct communication with possible future employers. They can be informed about all the relevant aspects of the STEM careers.

https://dihslovenia.si/cybergen-akademija-kmalu/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.16. Girls in STEM

Description

Girls in STEM project aims to awaken or deepen the love of seventh and eighth grade girls (13 to 15 years old) for mathematics and the natural sciences, but also to help them develop 21st century competences such as social skills, critical thinking, creativity and communication. The project is launched by Profil Klett and includes two main activities: knowledge competition which took place on International Women's Day, March 9 2020 and mini-research project that the students were supposed to carry out as a team following the stages of the research work, on a topic of their choice. Each team had to choose one topic, and after conducting the research, create a digital poster in the tool of their choice. The exposition of the posters should have taken place in April 2020 in Ogulin as a part of Science Festival, but Science Festival was postponed for October due to COVID-19.

Lessons learned for ENGIE:

The experience of this project can be transferred to many activities within the ENGIE project such as Science Club, Family Science Events. During the ENGIE activities, the girls can be encouraged to explore one topic related to the geosciences and to present the topic as poster.

https://www.profil-klett.hr/djevojcice-u-stem-u

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.17. Gender 4 STEM

Description

Croatian research institute Ruđer Bošković is involved in Erasmus + Programme co-funded International project "Gender 4 STEM – Gender aware education and teaching" that aims to create an e-learning platform where educational and awareness-raising materials would be available for use by secondary school teachers. Gender 4 STEM aims to tackle the low representation of girls in STEM education (Science, Technology, Engineering and Mathematics) and subsequently women in STEM careers. One of the reasons why STEM disciplines are unappealing to girls might be persistent stereotypes. The digital platform includes a self-assessment tool which enables individual approach and, depending on each teacher's profile, recommends learning content to help them better manage gender diversity in their classrooms. Gender4STEM brings together five European partners from Romania, the Netherlands, Luxembourg, Italy and Croatia with expertise in gender issues, e-learning and teaching, and technology Research & Development.

Within the project, Gender4STEM Teaching Assistant has been developed. It is a platform for teachers, providing them with concrete tools for more gender-fair teaching practices.

Lessons learned for ENGIE:

A platform for teachers, providing them with concrete tools for more gender-fair teaching practices is an idea that has been identified by ENGIE Project Consortium. Development of programme dedicated to advancement of gender sensitivity among secondary school teachers, allowing recognition and prevention of behaviours that often discourage girls from STEM careers, was planned as task T 2.5. The Gender4STEM Teaching Assistant starts with self-assessment tool that allows a teacher to assess the level of gender-fairness in his/her teaching practices. The approx. 10 minute 14 questions questionnaire is basis for personalised recommendations of materials that could help each teacher to increase gender fairness in their teaching. However, the questionnaire is designed as self-assessment, involving questions that the individual can hardly give objective answers to. For example, the teacher is asked to evaluate the following statement: "I am able to design concrete, fun and engaging STEM content (according to my domain) which ease learning and can break down misconceptions about gender (including stereotype threat intervention, gender roles, role models, etc.)."

https://www.profil-klett.hr/djevojcice-u-stem-u

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.18. STEM without fear

Description

High school in town of Požega is promoting their STEM oriented programs to girls by presenting interviews with female high school students who talk about their positive experiences. The interview was conducted with three female students in occasion of International Girls in ICT day because they all are interested in computer programming. These girls had some interesting point of view what can positively or negatively influence on the selection of profession in STEM area. They concluded that by choosing STEM areas, girls may encounter inequality between men and women. But by persistence and nurturing their interest in the area, they will not only participate in the fight against discrimination of women, but also what is very important provide a younger model for younger generations of girls in the STEM professions.

Lessons learned for ENGIE:

This program is very interesting for ENGIE because while interviewing young girls involved in STEM areas like programming or STEM in general can help us to find out their good and bad experiences dealing with it. At the same time, their positive experiences can be a good influence and encouragement on another young girls for choosing a career in STEM professions.

https://www.gimpoz.hr/hr/novosti/stem-bez-straha

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.19. STEM Little Explorers – Stem Activities for Kids

Description

STEM Little Explorers is an organization whose main goal is to give ideas for experiments and activities that are easy to make and cheap, so everybody can do them. Especially, they want to engage parents and teachers to do these activities with children because they are the greatest influencers on young children. So, the starting assumption is that if parents and teachers show interest in STEM, kids will soon fall in love with science, technology, engineering, and math and that will help them to choose one of those as a future career.

Lessons learned for ENGIE:

During the ENGIE project activities like Science Club, Family Science Events and outdoor activities like geo-scientific study are planned. So, most of the activities could be modified in a way that they include participation of enthusiastic teachers and parents.

https://www.stemlittleexplorers.com/hr/stem-mali-istrazivaci-stem-aktivnosti-za-djecu/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.20. STEM. GROW. EXPLORE.

Description

The program “STEM. Grow. Explore.” was jointly launched by the Znanje na Djelu (Knowledge in Action) Foundation and the Ruđer Bošković Institute. In addition to the program Institute also organizes “IRB Open day” with aim to familiarize young people with the STEM fields and its applications in everyday life, industry, and business. The Open Day is organized every year and it enables pupils and teachers to conduct a range of experiments in the Institute’s labs with scientists who encourage them to investigate and explore. Additionally, many companies introduce participants to the technological applications of science in industry.

Lessons learned for ENGIE:

The program is structured to involve the participation of Research Institute as well as Industry representatives who jointly present the possibilities that STEM careers offer, showing both the research and its application. It is reasonable to assume that this joint effort should have better results in raising interest of young people to STEM careers. So, there is evident need of introducing more women from industry in ENGIE activities.

http://znanjenadjelu.hr/en/program/stem-rastem-istrazujem/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.21. Croatian Makers Robotics League

Description

Croatian Makers Robotics League is IRIM's* (Institute for Youth Development and Innovativity) flagship project in robotics. It is the largest extracurricular STEM program not only in Croatia but in the European Union. Croatian Makers Robotics league is the largest competition of such kind in the EU. More than 550 schools with more than 150,000 children are included in the project. In the scope of the league the IRIM has donated more than 2,750 robots to the schools. The competition is organized in 4 rounds through the school year. In most schools the program is integrated into the curriculum. This concept proved to be very successful hence the Robotics League has been implemented in Serbia, Bosnia and Herzegovina and Kosovo by local partners (with IRIM's initial donations). In Serbia almost 500 schools participate, and the league has been mostly financed by Serbian government. The main aim of the League is to include robotics, automation, and programming into elementary school education.

*IRIM is a Croatia-based non-profit organization – private foundation with mission to empower all children in Croatia and the region to develop STEM competencies by providing equipment, education, and other activities. They have other projects / platforms like STEM revolution/ ProMikro, STEM Revolution – Grades 1 to 4, Digital Libraries for Local Development etc.

Lessons learned for ENGIE:

This program has evolved from the systematic and continuous effort of IRIM in developing STEM competencies in elementary school students. The program is being carried-out in schools as extracurricular activity which enabled involvement of many students. The program is spreading throughout the Southeastern Europe with Government support in some countries.

https://croatianmakers.hr/en/croatian-makers-league/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.22. Kitteens

Description

Kitteens – Electrotechnical and economic school Nova Gradiška, Industrial park and Osijek Software City NGO, have organized free educational workshops in areas of STEM within the project STEM Kitteens (https://kitteens.org/) in spring of 2019. Workshop with very significant acronym "Kitteens" was intended for girls aged 13 to 21, with the goal to stimulate their interest in science, IT technology, engineering, and mathematics. During interesting full-day workshop, 40 female students gathered new knowledge, experiences and skills and were taught how to work with micro bits, how to create a robotic arm and apply insights in 3D modelling. In addition to that, the workshop was an opportunity to empowering them to think about STEM professions.

Lessons learned for ENGIE:

Experiences from this project could be helpful during organization of activities like workshops, webinars and after school science activities.

https://slavonski.hr/stem-kitteens-za-novogradiske-ucenice-i-djevojkama-je-mjesto-u-it-tehnologijama/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.23. The DoMEn

Description

The DoMEn Cup is an online programming competition for primary and secondary school students organized by DoMEn d.o.o. and the Faculty of Science of the University of Montenegro. The competition is led by some of the best programmers and mathematicians in the country who work with young programmers, helping them with challenging problems. In this way the young programmers develop the critical thinking, resourcefulness and perseverance.

The competition is organized in three rounds and it is focused on task solving using the programming languages C / C ++, Java, Pascal and Python. As the competition is entirely online, it is open to all elementary and high school students regardless of the level of programming knowledge and the place of their residence. The DoMEn Cup champion is the student who collects the most points through all three rounds.

The first DoMEn Cup was held in 2018 and it was 24 hours long. There are no information on number of participants. Altogether 43 primary and secondary school students from Podgorica, Bar, Budva, Tivat, Nikšić, Berane, Bijelo Polje, Kolašin and Danilovgrad participated in the second DoMEn cup competition held in 2019. After the competition finished, the problems were available on-line, so that students who participated as well as those who didn't could use them for the exercise. The third DoMEn cup is organized through April and May 2020. The final number of participants is not yet known.

Lessons learned for ENGIE:

As many of listed initiatives that are aiming on raising the interest in STEM, this one is focused strictly on ICT and it is organized in the form of competition. The positive side is that it is organized online and that is shown to be very convenient because it enabled the competition to be held amid the COVID-19 pandemic. Making the problems available for exercise after the competition ended possibly enabled positive influence on greater number of students.

https://stemedukacija.me/domen-kup/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.24. Women in STEM – Decadal Plan

Description

"Women in STEM – Decadal Plan 2019-2028" is a report by the Australian Academy of Science, the Australian Academy of Technology and Engineering, and the members of the Expert Working Group addressing the common challenge that every organization in Australia (whether they operate in government, academia, industry, or the education sector) is facing: the need to tackle the significant under-representation of women in the STEM workforce. To achieve this, it is necessary to remove barriers to participation at every point of the STEM pipeline, creating an environment where girls and women can readily engage in STEM education and then use those skills to progress through their careers to senior level.

Three stages are identified where cohesive and collective actions must be taken to maximise the outcome: Attraction, Participation and Retention. The first one deals with encouraging girls and women to pursue STEM education and careers and ensuring they see STEM as a viable and exciting career pathway. Societal norms, teaching methods and careers' perceptions are seen as the main difficulties to reach this goal.

Six opportunities are listed where actions should be promoted: 1) Leadership and cohesion; 2) Evaluation; 3) Workplace culture; 4) Visibility; 5) Education and 6) Industry action. Equally representation of positive female role models in conferences and media is the most important action that can be envisioned for opportunity 4 (Visibility), while strengthening the education system to support teaching and learning on a national scale will drive opportunity 5 (Education) in that it enables and encourages all girls and women at all levels to study STEM courses and equip them with the skills and knowledge to participate in diverse STEM careers. The turning of the six outlined opportunities into actions will require commitment from all stakeholders: government, academia, industry, the education sector and the broader community.

Lessons learned for ENGIE:

Visibility and Education are the two identified opportunities where ENGIE will develop its actions. Successful programs as Science & Technology Australia Superstars of STEM or CASE Cessnock Academy of STEM Excellence and iSTEM are two of the case studied listed that reproduce ENGIE strategy.

Australian Academy of Science (2019).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.25. A Complex Formula

Description

The Report "A Complex Formula: Girls and Women in Science, Technology, Engineering and Mathematics in Asia" originates from the combined efforts of UNESCO and the Korean Women's Development Institute in seven Asian countries (Cambodia, Indonesia, Malaysia, Mongolia, Nepal, the Republic of Korea, and Viet Nam) to promote women's integration in STEM fields through their work in education. The fundamental question of the report is: What may influence the choices of girls and women to pursue STEM field of study and occupations?

The report recognizes that early and targeted interventions through education can greatly facilitate girls' and women's increased participation in STEM fields, as gender differences in performances are seen in students as young as 15 years old. The need of role models and STEM female teachers is of paramount importance as the *mise en place* of actions aiming at: 1) stimulating interest; 2) equipping teachers with more gender-responsive approaches and 3) taking policy measures.

Area where gender problems can arise are identified in three main fields: 1) Education (e.g. gender-responsive teacher-training in STEM-related subjects is lacking, similarly to scholarships and mentoring opportunities or learning materials still eradiate gender stereotypes); 2) Psychological influences (e.g. female may experience higher rates of anxiety around mathematics and science subjects), and 3) Labour market (e.g. unequal wages and concentration at lower levels).

The report lists also a number of key recommendations to Asian policy makers including enacting gender-responsive actions through education, promoting more female role models, training of teachers and revision of learning materials.

Lessons learned for ENGIE:

The focus on education is absolutely in accordance with our project's methodology and corroborates the need to focus on early stages of school pathways. The need of role models perfectly overlaps the positive examples embodied by successful women whose experiences' narratives are fundamental bricks of the project's actions for awareness increase.

UNESCO & KWDI (2015).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.26. Bedtime stories for rebel girls

Description

Storie della buonanotte per bambine ribelli (Italian for "Bedtime stories for rebel girls) is a book by Elena Favilli and Francesca Cavallo that presents the lives of 100 extraordinary women in the form of short fairy tales accompanied by colored pictures. The book has been translated into several languages and has sold more than 1,000,000 copies worldwide.

From the back cover: "Once upon a time ... there was a princess? Of course not! Once upon a time there was a girl who wanted to go to Mars. There was another who became the strongest tennis player in the world and another who discovered the metamorphosis of butterflies. From Serena Williams to Malala Yousafzai, from Rita Levi Montalcini to Frida Kahlo, from Margherita Hack to Michelle Obama, 100 women are told in these pages and portrayed by 60 illustrators from all over the world. Scientists, painters, astronauts, weightlifters, musicians, judges, chefs ... examples of courage, determination and generosity for anyone who wants to make their dreams come true."

Lessons learned for ENGIE:

The examples provided by women portrayed in this book (and others of the series) aim at encouraging girls to pursue their dreams without fear of difficulties and stereotypes they might encounter along the pathway. This is similar to what ENGIE wants to obtain with the positive examples provided by successful women in Geosciences and Engineering. The approach that unifies an original and entertaining storytelling with the account of real facts can be of inspiration for the creation of videos and/or reports collecting the stories of such successful women.

http://www.storiedellabuonanotteperbambineribelli.it/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.27. Technical Culture Festival

Description

The Festival della Cultura Tecnica (Italian for Technical Culture Festival) is promoted every year since 2014 by the Metropolitan City of Bologna and takes place within the "Guidance operations for educational success" promoted by the Emilia-Romagna Region and co-financed by the European Social Fund PO 2014-2020 (ref. PA 2019 / 12628 / RER). Its action sits in the wake of the project "The relaunch of technical education", enhancing education and technical and scientific training for young people, families, operators, stakeholders and citizenship.

The thematic focus of the 2019 edition, from 17 October to 18 December 2019, was on “Technique and gender” and the programmed activities were enhanced with the idea of refuting the stereotypes that girls are less inclined towards studying STEM disciplines and less interested in undertaking studies in technical professions.

Among the most interesting activities, the Treasure Hunt “Caccia al Futuro – La Tecnica è un gioco da ragazz…e” (Italian for Hunt for the Future – Technic is a girls’ game), organized in the opening day, was a team activity reserved to high school girl students in which participants were asked to solve several quizzes and puzzles of different technical-scientific disciplines.

Lessons learned for ENGIE:

Team activities and confrontation among peers are strongly encouraged to reinforce self-esteem and the perception of one's own abilities, as well as promoting teamwork as a successful problem-solving practice. ENGIE participants should consider this kind of activity among their actions.

https://www.festivalculturatecnica.it/il-programma-del-festival-della-cultura-tecnica-2019/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.28. IT Girls

Description

IT Girls is a project that encourages girls to start thinking about education and eventually potential career in the world of information technology. It was initiative of young employees of United Nations in Bosnia and Herzegovina. This idea was selected as the best one in the "UNder30 Innovation Challenge".
The basis behind the IT Girls initiative is in the cross-cutting commitment for the participation of women and girls in the job market and their equal involvement in all career opportunities. It was outlined in frameworks for protection and promotion of women's rights and national policies and legislation in Bosnia and Herzegovina (BiH).
The IT Girls project addresses the fact that women and girls are generally invisible in the Information and Communication Technologies (ICT) sector. One of the highest paying occupation groups in BiH, with the possibility of rapid growth, the ICT sector is highly male dominated.

Lessons learned for ENGIE:

This project encourages girls to take on STEM and especially in ICT and to start developing their skills from an early age. In addition, they organized competitions like #CodeLikeITGirl HAKATON and #TehnoMašta. The experience of this project can be transferred to many activities within the ENGIE project especially during organization of science events.

https://itgirlsbih.wordpress.com/about/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.29. MGiS

Description

Montenegrin Girls in STEM (MGiS) is project that is running in Montenegro under the Amplify.org.me (@amplify_org_me). AMPLIFY is organization that works in popularization of STEM among children and youth in Montenegro. Their work is characterized by using innovative and dynamic learning approaches.

One of the main goals of Montenegrin Girls in STEM is to offer after-school program to school students. This program is aimed at empowering young girls to discover STEM disciplines. Through this program 50 girls from elementary schools in Podgorica follow a 5-month program. Program is organized weekly and girls learn about robotics and programming. These educational workshops for children are free and oriented to fun presentation of STEM. During the workshops, children's logical thinking and problem solving is stimulated by construction of mini Lego robots, smart toys and puzzles.

Lessons learned for ENGIE:

The project organizes after-school program and workshops aimed at children, dominantly girls, weekly for five months. The emphasis is on gaining practical experience, i.e. learning by doing and that practice can be transferred to many activities within the ENGIE project, especially the planned after-school program.

https://codeweek.eu/view/208976/montenegrin-girls-in-stem-mgis
https://twitter.com/amplify_org_me?lang=bg

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

3.30. WiSci

Description

Women in Science Camp (WiSci) Girls STEAM Camp was organized in Pristina, Kosovo from August 18-29 in 2019. Girls from North Macedonia, Kosovo, Serbia, Albania, Montenegro and the United States gathered in Pristina, Kosovo to take part in the Women in Science (WiSci) Girls STEAM Camp. Camp is implemented by the United Nations Foundation's Girl Up program and with the support of organizations such as the U.S. Department of State, Intel, Millennium Challenge Corporation, NASA, Microsoft, and Bechtel. Around 100 girls and 12 counsellors from six countries participated in the camp. Through a variety of activities such as coding drones, creating short animated movies, and learning about artificial intelligence, participants learned about importance of science, technology, engineering, art and math (STEAM). In addition, participants met with representatives from leading companies in STEAM-related industries. These talks and activities motivated participants to take initiative and pursue careers in STEAM.

Lessons learned for ENGIE:

Through the Camp participants had opportunity to meet female representatives from leading companies in STEAM related industries. Such practice could be used as a model to organize a workshop with participation of female students and influential invited women from the fields of geoscience and related engineering.

https://bradleyherald.org/2019/11/06/flex-alumnae-at-the-women-in-science-camp-in-pristina-kosovo/
https://millenniumkosovo.org/mfk-visits-the-ministry-of-education-of-montenegro/

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.

Conclusions

In its aim to turn the interest of girls to study geosciences and geo-engineering, the ENGIE project needs to take inspiration from and develop best practices to approach students and teach them STEM-related subjects. For this purpose, a thorough research has been put into place to define best practices used in Europe and worldwide for attracting and consolidate students' and girls' interest in STEM. It became evident that interest is a complex interplay between affective and cognitive components, that drive motivation. Specifically, student interest tends to be initially triggered from an external agent (e.g., an engaging instructor or experience), but will not develop into a more sustained, individual interest unless it is repeated, engaging, and intellectually stimulating (**1.1**). The challenge of the ENGIE project will then be that of providing such stimulating experiences in the framework of its planned actions. Several important lessons have been learned and can be used for ensuring the success of ENGIE's initiatives and the reaching of its goals. They have been grouped into five general themes and are described in the following part. Dataset entries are linked by their associate number in bold character (see above).

1. **Avoid any kind of gender bias.**
   Obviously, the most important lesson learned is that any kind of gender biases has to be avoided, not only those directly affecting girls and women but also those that, viceversa, ultimately exclude boys and men from activities and awareness actions just because they are male (**1.3**, **1.11**, **3.24**). Indeed, inclusion must be THE keyword at the basis of ENGIE partners' efforts. One of the most important efforts to be promoted in the framework of ENGIE's activities is that of preventing the substitution of ancient stereotypes (e.g. girls can't be successful geoscientists and geoengineers) with new ones (e.g. ALL girls and women can satisfactorily pursue a scientific careers), a very tricky pathway where one can easily fall. The participation also of teachers and male students to awareness actions aimed at strengthening girls' perception of their potential in STEM fields is a precious occasion to further educate all teachers and students to gender equality and to make them gain direct experience of the higher levels of creativity and innovation that usually accompany heterogeneous and diverse teams (**1.3**, **1.10**, **1.11**, **2.2**, **3.10**, **3.12**). The aim of open events and in general of all visibility and education actions is that of providing also families and the general public with this new consciousness that can finally trigger important institutional and cultural changes (**2.17**, **3.12**, **3.14**). Similarly, train-the-trainer approaches and those involving strong national networks between researchers, teachers, and other stakeholders are very effective in addressing large number of students and ensure the long-lasting legacy of educational projects in school systems (**2.2**, **2.17**). The ENGIE Project

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Consortium intend to provide teachers with a dedicated platform where concrete tools for more gender-fair teaching practices can be retrieved. In addition, the development of a programme for the advancement of gender sensitivity among secondary school teachers is also planned.

2. **Presentation of positive examples provided by both successful researchers/women and peers.**
The positive effect that role models have on youngsters is well acknowledged by the ENGIE project that, indeed, intends to collect and disseminate interviews of successful women in the field of geosciences and geo-engineering to attract and encourage girls into pursuing similar careers. The passionate story-telling of what moved people into a specific study area, how they faced and overcame difficulties and prejudices provides a powerful message to teenagers that struggle to find their way into the world or are scared that what really interest them is not what they are expected to do (1.1, 3.3, 3.4, 3.6, 3.9, 3.11, 3.18, 3.25, 3.26). The "connection to the Earth" term of the affective domain at the basis of stable and long-term interest (1.1) is strongly linked to the examples provided by senior professionals (2.28, 3.3, 3.4, 3.6, 3.9, 3.25, 3.30) and young girls involved in STEM areas (3.18), and this becomes particularly important when these examples are provided by accomplished female professionals working in traditionally male industries (3.9, 3.20, 3.30), making the partnership/collaboration with industry highly advisable on this respect. The way these stories are told can be a critical point: the message should be sincere (no omissions), clearly stated and, why not, entertaining. Media (3.11), social media (2.16, 2.17, 3.5) and other original communication forms (3.26) are suggested or can be used for the creation of videos and/or reports collecting the stories aimed at providing inspirational examples.
Similarly to role models, the mentoring of teenage school girls by their older undergraduate peers (1.6, 2.1, 2.3, 3.1, 3.2, 3.3, 3.18, 3.27) can create positive feedbacks, with the additional bonus provided by age proximity that can facilitate communication and emotional/knowledge transfer. This approach and the use of team work (2.7, 3.7, 3.27) are advisable for ENGIE activities, as ways to reinforce self-esteem and the perception of one's own abilities. The mentee-mentor interaction can be also translated into a researcher-teacher relationship in the framework of the ENGIE project, in order to increase the latter's school curriculum with STEM topics (3.3, 3.17).

3. **Focus on active learning strategies and hands-on activities.**
Hands-on activities and the direct, first-person experience of the researchers' job through active learning have been first suggested and then found to be among the most effective practices to increase and turn individual interests into stable, long-term professional choices (1.8, 1.11, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12, 2.15, 2.16, 2.27, 2.29, 3.29, 3.30). Special attention must be

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paid into developing emotional connections with the offering of activities and experiences that pertain to students' everyday life, help breaking cultural barriers, and attain vocations' promotion. In addition, the development of prosocial goals is another aspect to be considered when programming such activities, since it is especially suited for students (and girls among them) who aims at interacting with others (1.1). The use of funny and amusing tool kits is strongly advised in the framework of school and community programs. These latter could provide an additional bonus as they can strengthen family bonds and create positive memories that will be connected to the experience lived with the loved ones. In addition, modern technologies (2.18, 2.19, 2.20, 2.21) and social media (2.16, 2.17, 3.5, 3.29) are efficient ways of reaching out young generations and capture their attention. Their use should be at the basis of most activities proposed.

4. **Organization of activities and use of new/updated technologies and approaches.**
Whether they include field trips (2.3, 2.5, 2.6, 2.7, 2.8, 2.9, 2.11, 2.27), classroom lessons (1.4, 1.9, 2.11, 2.12, 2.14, 2.16, 2.17, 2.23, 3.7, 3.13, 3.16, 3.19, 3.21) or after School programs (2.10, 2.13, 2.15, 2.16, 2.17, 2.24, 2.25, 2.26, 2.29, 3.14, 3.15, 3.16, 3.20, 3.22, 3.23, 3.27, 3.28, 3.29, 3.30) all activities proposed to students in order to attract them to STEM topics need to be carefully organized and tested, in order to ensure the success of the initiatives and the reaching of the goal. For example, the model developed for planning and implementing field trips recognizes three learning cycles (1. the preparatory unit; 2. the field trip; and 3. the summary unit) that have successfully inspired several similar initiatives (2.5, 2.6, 2.7, 2.8, 2.9) but that can be used also in different contexts when appropriately modified. Similarly, the 5E learning cycle model (Engagement, Exploration, Explanation, Elaboration, Evaluation phases) developed for chemistry teaching (2.23) can be tailored to fit in other subjects. The principles at the basis of these two models generally well overlap and can therefore answer to different teaching needs. Indeed, the preparatory unit or the Engagement and Explanation phases are always necessary to reduce the so-called "novelty space" associated with every new experience that, if not dealt with, can be quite disorientating and difficult to follow (1.4, 2.7). Field trip teaching practices of "Teaming-Up" (2.7), outdoor manual activities (1.9, 2.6), and the Exploration phase (2.23) can be translated into a wide range of different activities (e.g. classroom training, after School actions) where single participants or working groups are involved. Finally, both the summary unit and the Elaboration and Evaluation phases want to assess the attained knowledge building and acquisition, mainly through tests and/or satisfaction questionnaires. The organization of activities with students and the general public should also consider the special needs that some participants might present (2.8) and provide remediation measures accordingly. Many of the programmed ENGIE activities (e.g. Researcher's Night, Science Clubs, Family Science Events) could benefit from these models and ameliorate their outreach goals.

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The use of modern Information Technologies (ITs), developed for learning and entertainment purposes (**2.18**, **2.19**, **2.20**, **2.21**, **2.25**, **2.29**, **3.29**), and alternative teaching approaches (**1.12**, **1.13**, **2.13**, **2.14**) are strongly encouraged as they can motivate the audience and capture their attention more effectively than traditional ways. The use of an easy language and of precise tools and strategies is mandatory (**1.2**, **1.5**) because when a clear link to the audience's life styles and expectations is made, the importance of Science and Research work is better understood and the interest in the discussed topics increases.

5. **Empowering students through the exposure to Science.**
   As a way to provide engaging and stimulating experiences that can trigger initial interest in Science into a more sustained individual interest in a related profession (**1.1**), the involvement of students in real scientific work is highly advisable. Indeed, students best consolidate their knowledge when they apply what they have just learned or have to explain it to someone else (**1.7**, **2.4**, **2.22**). This latter engagement causes students to become Science popularizers themselves and its outcomes have been successfully experimented in several occasions (**2.16**, **2.17**, **3.16**). In addition, students' involvement in the organizations of events and activities has been proven to be a very satisfactory experience for them, as they have the opportunity to show their achievements, and boost their self-confidence in the fields of Science (e.g. Young Ambassadors in the framework of RM@Schools project; **2.16**). In addition, students are made responsible by adopting ethical scientific principles involving the transfer of correct and sound scientific knowledge to the public with the aim of raising awareness and providing reliable instruments for the understanding of the world around them (**1.5**).

   Another option to empower students in a funny and engaging way is that of organizing scientific competitions of various kinds, with awards and bonuses for the winners (**2.17**, **2.26**, **3.8**, **3.13**, **3.15**, **3.16**, **3.23**, **3.28**). The creativity skills that are ignited by these contests can either motivate and encourage further education in STEM fields: participants will likely explore the contest's subject in other ways than those proposed, thus autonomously acquiring more information and knowledge. A further advantage of scientific competitions is that they can be organized online, allowing them to be held also amid lockdown conditions and with enforced social distancing rules (**3.23**). The photo contest that will be organized in the ENGIE project perfectly fits in this scenario.

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