STEM FOR YOUTH

THE FUTURE OF THE EUROPEAN LABOUR MARKET IS CALLED STEM

WE HELP YOUNG PEOPLE IN TAKING CONSCIOUS DECISIONS ABOUT THEIR FUTURE

INSIGHTS FROM THE FINAL CONFERENCE

MILAN

11th OCTOBER 2018

WHILE THE 20TH CENTURY BECAME KNOWN AS THE AGE OF SCIENCE, THE 21ST CENTURY IS BROADLY RECOGNIZED AS THE AGE OF INFORMATION TECHNOLOGY

Saying that the world is changing may sound cliché, but that is exactly what is happening right now. Even scientists and experts find it hard to keep up to date with scientific breakthroughs and innovations.

Let's turn our focus for a while on how such information and innovations are conveyed and disseminated, at least at school level. How has education changed during the past hundred years? The answer, sadly, seems to be not too much. At least, not enough to communicate science as attractive and exciting, as we wish to do as science professionals and communicators. Not enough, in the end, **to prepare future students and citizens to live in the modern, full connected society**.

This point seems to represent an unsolved paradox. As specialists involved in science, we believe STEM subjects have the power to give a deeper understanding of the world, as well as the chance to change it. However, at the same time we are faced with a major problem at school level: several scientific subjects are seen as too difficult or, even worse, a prerogative of the most talented students. For this reason, **the perceived detachment of STEM fields from real life** significantly limits the opportunities available to young people and often creates misperceptions of what STEM education really is.

Miroslaw Brzozowy
STEM4youth Technical Project Manager,
Politechnika Warszawska

Alessandro Vitale
STEM4youth Head of Communication
and Dissemination, Fondazione Umberto Veronesi

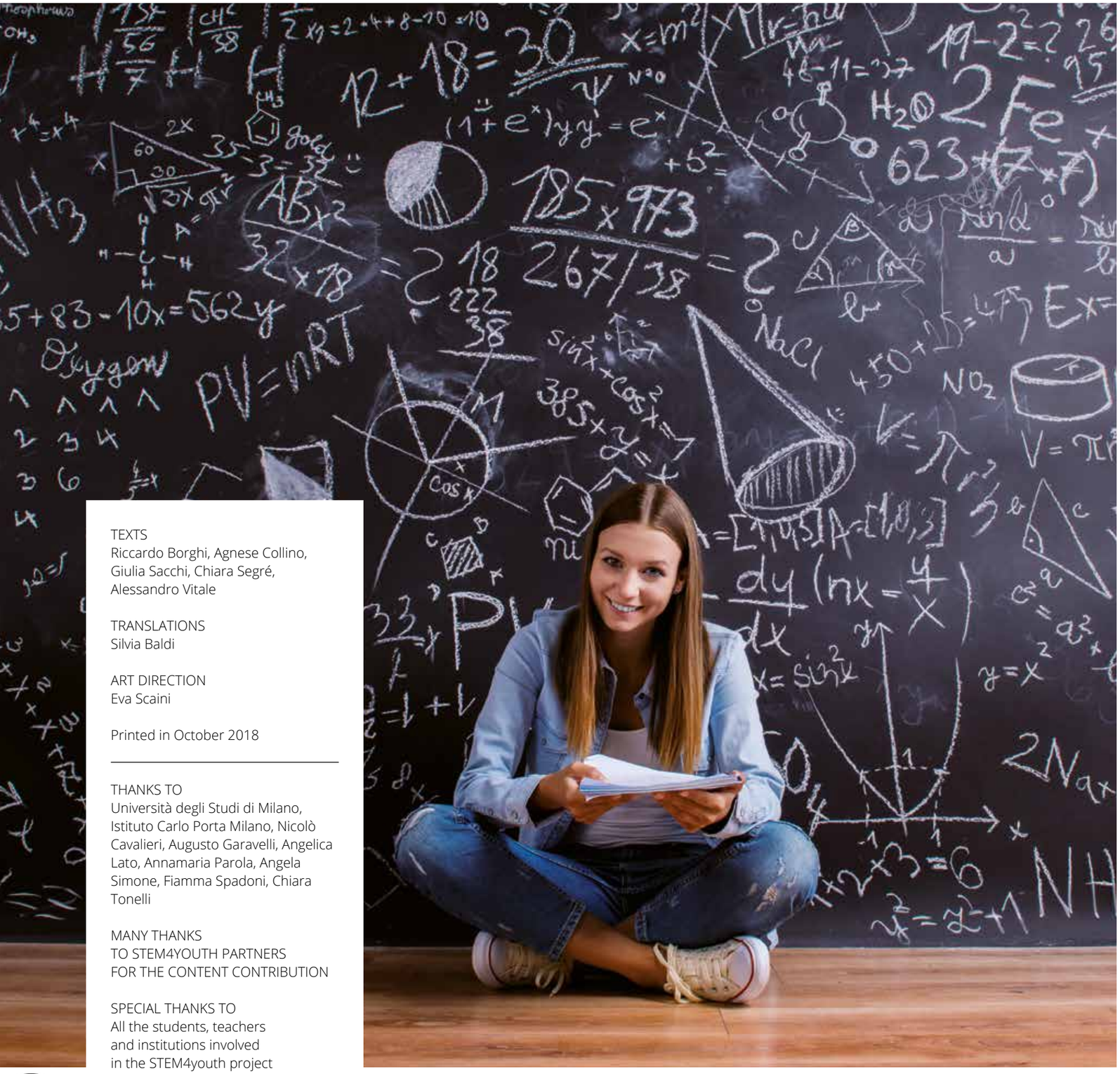
The goal of STEM4youth, a project financed under the EU Horizon 2020 Programme, is to radically change the current situation. Over the last two years, we have focused on STEM (Science – like Physics, Chemistry, Astronomy or Medicine – Technology, Engineering and Mathematics) trying to offer **a fresh perspective on these topics to young pupils and students**. Instead of traditionally taught lectures that merely deliver knowledge as is, we have taken advantage **of modern learning methodologies** (like enquiry-based learning, the engineering design process, project-based learning, learning by playing) and information technology tools to stir young people's **curiosity** into STEM, foster their creativity and develop their logical and **critical thinking**. In other words, STEM4youth offers a series of multimedia, multidisciplinary courses for high-school teachers and students to support their formal and informal education.

Equally important, our project also supports students in pursuing **STEM careers** by providing comprehensive information on the most prominent skills developed in STEM education, as well as addressing the expertise required by the STEM labour market. We have characterised these careers paths to show young people how their future work may look like. We believe this information may help youngsters to take conscious decisions on their interests and future careers.

The STEM4youth approach is not purely theoretical. It was developed by European universities and foundations with extensive experience in STEM promotion and in cooperation with high schools. While the project often refers to innovative learning methodologies, all these methods have already proved to be effective in practice. What's more, our content and learning platform OLCMS is open: anybody can upload and share their own contents or customise existing ones according to their needs. If you are looking for new ideas for your lessons, this project is definitely for you!

If you are a student and would like to gather a more holistic view on STEM, or to learn what your future career might look like as a STEM graduate, please have a look at our platform as well.

We wish you all the best in your efforts to become anything you want to become. Our mission is to do our very best in supporting you and your future decisions.



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SPECIAL THANKS TO
All the students, teachers and institutions involved in the STEM4youth project

STEM FOR YOUTH

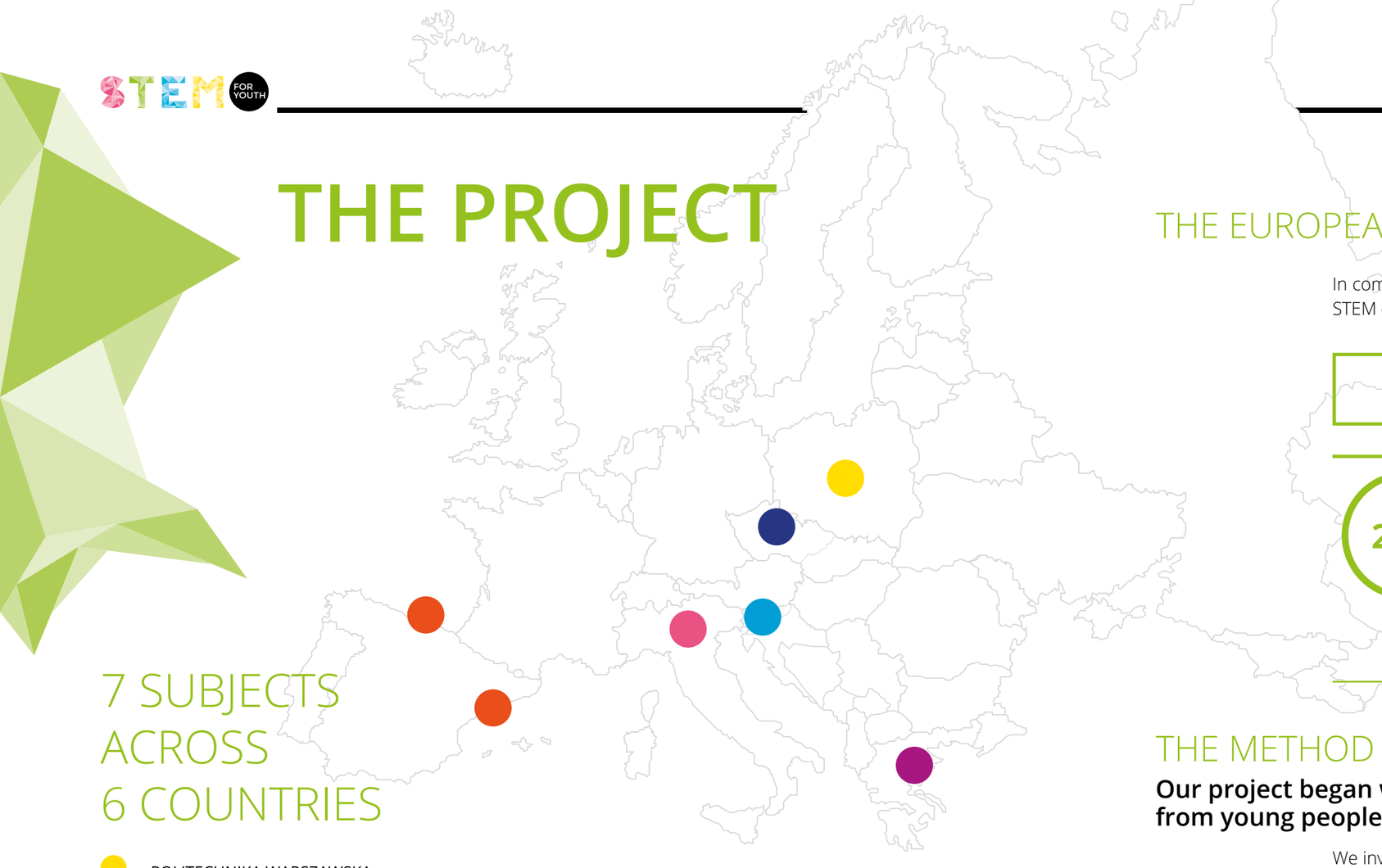
ENJOY. SCIENCE TECHNOLOGY ENGINEERING MATHEMATICS.

www.stem4youth.eu

A passion that begins when you are young.

A career that continues when you are older.

THE PROJECT



7 SUBJECTS ACROSS 6 COUNTRIES

- POLITECHNIKA WARSZAWSKA
- TECHNICKÁ UNIVERZITA OSTRAVA
- INŠTITUT ZA RAZVOJNE IN STRATEŠKE ANALIZE
  INŠTITUT JOŽEF STEFAN
- EUGENIDES FOUNDATION
  RESEARCH PATHS
- FONDAZIONE UMBERTO VERONESI
- UNIVERSITAT DE BARCELONA
  UNIVERSIDAD DE CANTABRIA
  OPEN EVIDENCE

THE EUROPEAN SITUATION

In comparison with the emerging countries, European countries show less interest in STEM disciplines.

PEOPLE WHO STUDY SCIENCE OR TECHNOLOGY SUBJECTS

- 20% ASIA
- 2% EUROPE

STUDENTS WHO WANT TO BECOME SCIENTISTS OR WORK IN SCIENCE & TECHNOLOGY

- DEVELOPING COUNTRIES: 60% 90%
- DEVELOPED COUNTRIES: 30% 20%

THE METHOD WE HAVE ADOPTED

Our project began with an analysis of what employers require from young people.

We involved teachers and students in learning STEM subject in an innovative way and we wanted to share with them two fundamental concepts: STEM disciplines can be "cool" and allow you to start to pursue a career with a higher salary potential.

THE SOLUTION

We bring teenagers closer to science and technology.

Thanks to our activities students will get a fresh look on science and acquire a better undestanding of how the world functions through scientific mechanisms.

WHAT WE CREATED

We developed school courses in **seven STEM subjects**, a teachers toolkit, urban happenings and pop-up installations, events, an open source educational platform and social networks, to make science and technology fun. The project has ended with **a call to public authorities to adopt the best STEM educational methodologies at school.**

Gender role models in STEM. Inspiration or threat?

Wendy Sadler
Director *Science made simple* - Lecturer Cardiff University

BACKGROUND

It is well-reported that the number of women pursuing careers in the physical sciences and engineering is in the minority.

Across the UK **less than 20%** of engineers are women and only 22% of those taking A level Physics are female[1]. In Europe the numbers are similar in most countries.

With the overall shortage of graduates in these areas, much effort has been spent on trying to even the balance. With the shortage being so large, the rationale has often been that appealing to only 50% of the population (male) will not help solve the problem of supply to the STEM industries. In addition to solving the STEM skills gap, there is evidence that more diverse teams perform better and that at the very highest level **women have a positive impact on organisational success**[2].

Are careers in STEM for people like me?

One of the ways that has been used extensively to tackle this issue is the use of role models working in STEM to show young people a more diverse range of scientists and engineers.

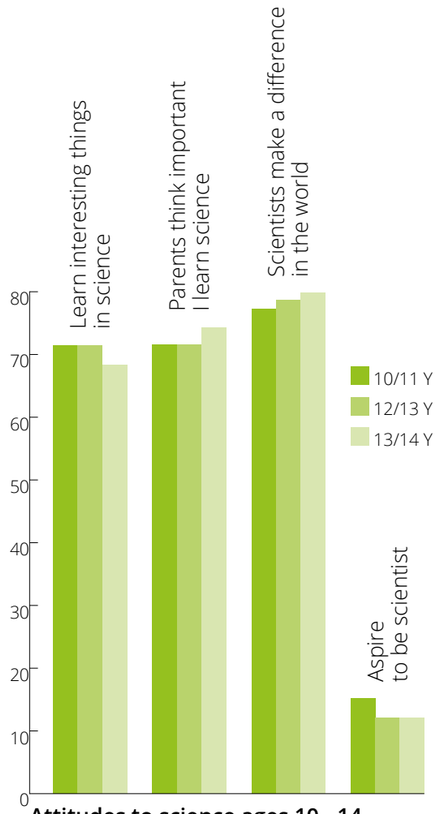
There is evidence to suggest that a large number of young people **still hold negative views of scientists and engineers**. Many young people though use positive words to describe scientists (eg useful, clever, helpful, creative) but still do not self-identify as someone who could do science.

They feel strongly that careers in STEM are *"not for people like me".*

WHAT DO WE KNOW?

One of the largest studies of student attitudes to STEM is an ongoing study in the UK called "ASPIRES". This has been tracking attitudes and career aspirations in over 7000 young people since the age of 10. Some of the results to come out so far include the conclusion that the level of "science capital" held by a young person is by far the largest indicator of whether they will go on to a career in STEM[3]. Science capital is measured using a number of indicators including scientific literacy, attitudes, behaviours and social contacts[4].

The results of this study have started a shift in the methods used to tackle the diversity issues in the UK. There was previously a belief that students felt science in school was boring or not relevant to them – but this study showed that this was not the case. The main issue was that despite positive thoughts on science **in schools almost no students saw themselves as scientists in the future**. The problem that needs addressing it seems more than any other is the self-identity young people have and the fact that they think a job in science is "not for people like me". This is the case for both genders but is more even more of an effect with girls. One of the reactions to this research has come from an initiative by WISE (The Campaign for Women in Science and Engineering, UK). After commissioning a summary of research, they released a report called 'People like me5' and have followed up with a project of the same name which tries a slightly different approach. The workshop, which is aimed at girls only, gets girls to use positive adjectives to describe their own personality. The aim is to get across the messages that you are more likely to be happy in a job if the job skills required match your natural skills and characteristics. The answers to the quiz give the girls a job-type and then gives them **case studies of women working in those type of roles within STEM organisations**. As well as getting the girls to think of careers differently, the activity aims to show students that studying science can lead to many jobs that might use science skills without being the narrow definition of working in science that they have.



Attitudes to science ages 10 - 14
(ASPIRES)

Role models actually de-motivated young girls

Using role models to promote a range of opportunities in STEM to girls is nothing new. Sometimes however the role models used can create an additional problem.
By trying to overturn the nerd/geek image organisations deliberately choose high achievers and aesthetically beautiful women as representations in STEM.

The danger here is that not only do young people think you have to be very clever to work in STEM, it now appears you have to be beautiful and thin as well!

Research has shown that using ultra-feminine versions of women in STEM as aspirational role models is not a good idea for many girls.
In the paper "My fair physicist" [6] it was found that feminine STEM role models actually **de-motivated young girls because the combination of career success and femininity seemed especially unattainable.**

CASE STUDY OF USING ROLE MODELS IN SCHOOL ENRICHMENT

In 2004, the social enterprise science made simple received funding from the Welsh Government in partnership with WISE to develop a touring STEM show for 7-11 yr old students featuring real-life scientists and engineers in short videos talking about what they do and why they enjoy it.
The show is called "Who wants to be a superhero?" The show also includes live science experiments and audience interaction and is presented by a live presenter (who could be male or female). In 2013 the show was updated and new videos were made and the revised show was then toured to 60 schools.
Attitudes to STEM and the scientists in the show were collected from **363 students** and then follow-up focus group interviews were held with 4 groups of 6-8 students each to explore the themes that came up from the questionnaire results.
The aim of the study was to find out **whether the show affected student attitudes to scientists based on the descriptive words that students used to describe them**. In addition, we wanted to find out if students favoured role models who they thought were most like them, or those who they felt had the job they would most like.

Students were asked if they would like a job in science or engineering before the show and after. **Across all students there was an increase from 18-30% in those who would like to work in STEM with a bigger increase coming from the girls** (increase from 10%-25%) than the boys (from 24-35%).

TABLE 1

Would you like a job in science or engineering when you're older?

	ALL (%)		GIRLS (%)		BOYS (%)	
	Pre-show	Post-show	Pre-show	Post-show	Pre-show	Post-show
Yes	18	30	10	25	24	35
No	32	18	33	17	32	21
Maybe	50	52	57	57	43	43

The three words used by the students to describe scientists and engineers before and after the show were analysed and divided into positive, negative and neutral. **The number of positive words used also increased after the show** – again with a larger increase from the girls. The number of negative words used also decreased suggesting that overall the show had shifted the attitude of both genders towards a more positive response.

TABLE 2

Words used to describe scientists pre- and post-show

	GIRLS (%)			BOYS (%)		
	Pre-show	Post-show	**Diff.**	Post-show	Pre-show	**Diff.**
Positive	28.91	42.39	**+13.48**	31.76	39.66	**+7.90**
Negative	4.95	2.14	**-2.81**	7.43	5.38	**-2.05**
Neutral	66.14	55.47	**-10.67**	60.81	54.97	**-5.84**

TABLE 3

Most common words describing scientists, as a percentage of total responses before and after the show

	GIRLS (%)			BOYS (%)		
	Pre-show	Post-show	**Diff.**	Post-show	Pre-show	**Diff.**
Clever, Talented, Intelligent	43.63	39.55	-4.08	47.69	39.87	-7.82
Awesome, Cool, Inspiring'	11.49	18.36	+6.87	10.12	21.51	+11.39
Hardworking, Ambitious, Focused	6.56	7.10	+0.54	6.30	5.91	-0.39
Creative, Designers, Pioneers'	6.08	4.87	-1.21	7.76	6.92	-0.84
Dangerous, Brave, Strong'	5.89	3.75	-2.14	4.39	3.65	-0.74
Helpful, Important	4.44	6.80	+2.36	2.92	5.79	+2.87
Nerdy, Crazy, Evil	4.82	3.55	-1.27	4.27	1.76	-2.51

By looking in more detail at the words used we can see that the most significant changes came in the use of the words that implied inherently high levels of intellect are required for science.
These words reduced by 4% from boys and nearly 8% from girls. In contrast the aspirational words about the role models (Awesome, Cool, Inspiring) increased by almost 7% for the boys and over 11% for the girls. This suggests the show did manage to shift attitudes to show that a job in science might be an attractive possibility.

The show is specifically designed to promote the message that scientists and engineers are helpful people who want to make the world a better place.
Words relating to this societal role increased slightly (around 2%) in both boys and girls.

CONCLUSIONS & FURTHER RESEARCH

The use of role models as a way to encourage young people into STEM is a widely used tool. This research tried to understand in more detail what changes might occur when primary school students encounter role models in STEM.

The survey data shows clearly that both genders enjoyed the show and could relate to one or more of the role models. It showed us that boys tend to favour male role models whilst girls choose females - although not exclusively. An interesting point arose in the focus groups where a **number of students mentioned risk and danger as a reason why they might not choose STEM careers**. This is something educationalists and scientist should keep in mind. As most of us behind role model projects are scientists or engineers at heart, we tend to choose role models that we think have an exciting job and perhaps we don't feel the same way about the risks encountered as the students do. This area could benefit from further research to help prevent us putting off young people with jobs they perceive to be too risky.

Scientists are not only clever and intelligent. They can be cool and inspiring too.

The intervention of a live performance featuring videos of real people (4 female, 2 male) seemed to be successful at reshaping how the students describe scientists and engineers. **They moved from seeing them as purely 'clever' and 'intelligent'** (properties that many young people think you are either born with or not) **to 'cool' and 'inspiring'** (something more people would aspire to).

We collected data from the students before the show on whether they knew anyone who worked in a STEM job. We have yet to analyse how this affects the words they use, or whether they themselves could imagine themselves as a scientist. As knowing someone in a STEM job is likely to increase the Science Capital of the student, the theory would predict that they are more likely to be positive about jobs in the field. It should be noted though that many students who said they knew someone in a STEM job were actually referring to a builder, plumber of carpenter – trade professional. These jobs certainly contain STEM elements but are perhaps not those that are referred to as STEM professions.

Wendy Sadler, MBE, is the founding Director of science made simple – an award-winning social enterprise that offers science shows to schools and families across the UK and internationally. The company has a serious mission to inspire the next generation of scientists and engineers and to raise the profile of STEM within popular culture. She is also a lecturer in Science Communication and has a research interest around increasing diversity in the physical sciences.
Science made simple was awarded an EU Descartes prize for innovation in science communication in 2004.

Further evaluation has been done on the effectiveness of the WISE People Like Me workshop with an older, female only audience.
This work found that 57% of the girls reported that they were now more interested in studying science and maths at school, and the percentage who were not interested at all had decreased from 10% to 4%. In this study, the girls were also asked to use words that describe a scientist. 'Interesting' was the top response (98 mentions) followed by 'clever' (26) varied (25) and useful (23)[7].

There is more work to be done on exactly what can help the most in the use of role models as agents for change in attitudes to STEM and STEM careers but these two case studies provide some interesting areas for thought and further research. Clearly role models have an important part to play – providing they are used in an appropriate way. But they should not provide another difficult stereotype for girls or boys to live up to. **A wide range of gender, race, social background and character are key requirements for any campaign to encourage more diverse students to feel that science certainly is for 'people like them'**.

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USEFUL LINKS

1 Information on science made simple and 'Who wants to be a superhero?' show www.sciencemadesimple.co.uk
2 Information on the WISE Campaign 'People like me' initiative https://www.wisecampaign.org.uk/what-we-do/expertise/inspiring-girls-with-people-like-me the-evidence-and-why-it-works/

Science career plans of adolescents: patterns, trends and gender divide

Federico Biagi
CRELL - Centre for Research on Education and Lifelong Learning - Team Leader;
European Commission JRC B.4 - Human Capital and Employment Unit

Career plans and aspirations tend to work as self-fulfilling prophecies and guide educational choices, course-taking decisions and efforts devoted to studies and self-development.
They are also good predictors of future educational and employment patterns. In essence, if we want to better understand what drives employment in STEM, we need to start by looking at educational aspirations.
To do this, we have used **PISA 2006 and 2015 data focusing on STEM-related career choices**. In our analysis we have made a distinction between core STEM occupations, which in our work are Science and Engineering Professionals and Associate Professionals (ISCO 21 and ISCO 25) and Information and Communications Technology Professional and Associate Professionals (ISCO 31 and ISCO 35). We have also looked at Health Professionals and Associate Professionals as separate occupational groups.
The first finding is that, in 2015, on average, **20% of 15-year-old students in Europe** planned to pursue a science-related career. However, considerable differences exist across countries, with country averages ranging between 12% and 27%.
Moreover, **there is a remarkable difference between males and females**, with the average gender gap reaching 19 percentage points.

Federico Biagi is currently CRELL Team Leader at JRC Unit B.4 - Human Capital and Employment - based in Ispra (Italy). He has developed a significant understanding and advanced skills in general public economics, economics of education, labour economics, applied economics, industrial organisation, growth theory, econometrics and impact assessment.
In addition, Federico has gained extensive experience in working with large datasets. His current work is focused on inequality in education and on policies to address it.

On average, European males are three times more likely to choose a STEM occupation than European females.

A gap favouring males was identified in every Member State, varying only in size, and with a minimum of 15 and a maximum of 31 percentage points. On the other hand, **a gap favouring females is found in Health-related professions**.
When we consider the drivers of STEM career choices, several individual characteristics appear as relevant, science ability being the single most important factor. Attitudes towards science also play a pivotal role.
Among family characteristics, parental employment in STEM and migration status are also significantly related to STEM career choices.
School resources do not seem to affect educational choices towards STEM. However, in a number of countries, students who are on a vocational track at the age of 15 are increasingly interested in choosing a STEM job.
Between-country comparisons further reveal that this influence is particularly strong and positive in countries where upper secondary vocational programmes offer a relatively smooth transition to higher education.
Finally, we have found indications that the share of 15-year-old students on a vocational programme and **the existence of a compulsory national examination in mathematics are positively related with STEM career choices.**

The work "Science career plans of adolescents: patterns, trends and gender divides" is authored by two members of CRELL - Artur Pokropek and Zsuzsa Blasko - and by Professor Joanna Sikora, Australian National University.

STEM EDUCATION: IDEAS FROM THE MAIN ACTORS

Brussels, Belgium

Science Programme Manager
and Head of the Science Education Department,
European Schoolnet

AGUEDA GRAS-VELAZQUEZ | GUEST #1

STEM is what makes our world function, our lives better and longer...

As Head of the Science Education Department at EUN, Agueda is in charge of overseeing and coordinating all the Maths and Science projects in which EUN is involved. Additionally, she is in charge of the day-to-day management of Scientix (the community for science education in Europe, http://scientix.eu).
She coordinates EUN's Ministries of Education STEM representatives Working Group and, since January 2017, she also manages the European Schoolnet Academy. In her over 10 years at EUN, Agueda has been involved in over 35 European Commission funded projects and 13 privately funded ones. She also sits on the advisory board in the advisory board of a number of projects. Prior to joining EUN in May 2008, she worked as an independent eLearning professional, tutor, content designer, IT manager, administrator, project Manager and consultant for international projects. She has co-authored several papers in the area of Science Education Research and has a PhD in Astrophysics from Trinity College Dublin, which she carried out at the Dublin Institute for Advanced Studies in Ireland.

1 • When did you realise you wanted to pursue a career in STEM?

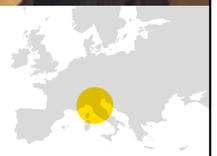
2 • What is the most important aspect in STEM education for young people among your present agenda?

3 • In your opinion, what are the most desirable changes to STEM education in the nearest future?

1 I decided I would follow a STEM career when I was around 14 years old. I always liked Mathematics, following extra courses when possible. My first memory of this dates back to when I was 9 and living in the United States. My parents asked me what I wanted to do during the summer break and I said I wanted to take a Mathematics course! However, it wasn't until high school that I was convinced I would go into academia in the area of STEM.

2 The key is understanding that Science, Technology, Engineering and Mathematics are everywhere in our lives. They aren't simply a set of compulsory subjects but the keys to what makes our world function, our lives better and longer.
How to connect STEM classes to real life situation is actually the topic of the upcoming Scientix MOOC "STEM is Everywhere!". We want to help teachers improve their classes by connecting them with everyday uses of STEM, from the kitchen to transport, sports and the management of supermarkets!
You can find out more about this online course here:
www.europeanschoolnetacademy.eu/web/stem-is-everywhere

3 I want all students to understand the importance of STEM for our lives, whether they pursue STEM careers or anything else they like.



Milan, Italy

Director of Education of the Centre of Research in Informal Education, National Museum of Science and Technology Leonardo da Vinci; Member of ECSITE Spokes Editorial Committee

MARIA XANTHOUDAKI | GUEST #2

How important education is in creating consciousness, knowledge and a critical stance...

Maria began building her career and experience in science museums in 2001 at the National Museum of Science and Technology Leonardo da Vinci, first as a freelance advisor and since 2006 as Director of Education.
In her current role, she collaborates with the leading science museums in Europe and the United States, such as the Deutsches Museum, Universcience in Paris, the London's Natural History Museum and Wellcome Trust, the San Francisco Exploratorium and the Museum of Science Boston. Maria has also held academic positions, beginning as Senior Research Associate at the School of Education and Professional Development of the University of East Anglia (UK), as researcher at Milan Polytechnic, and for 10 years as expert fellow at the BA course "Economics for Arts and Culture" of Bocconi University. She has taught several several BA - or postgraduate-level courses at the Scuola Normale Superiore in Pisa, the University of Siena and the University of Milan Bicocca. From 2004 to 2016 she coordinated the In-service training course SMEC "School-Museum Cooperation" for museum professionals and teachers, which trained 300 professionals from 40 countries of Europe and beyond.

1 • When did you realise you wanted to pursue a career in STEM?

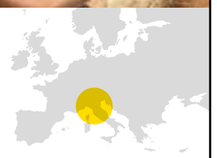
2 • What is the most important aspect in STEM education for young people among your present agenda?

3 • In your opinion, what are the most desirable changes to STEM education in the nearest future?

1 My background is in pedagogy and I have been working in the field of museums, starting from art and then moving on to science museums. This means that I am 'looking' into STEM from an education and learning point of view rather than from the point of view of STEM-oriented contents.
Since my degree, education and pedagogy have been at the core of my studies and professional interests. However, I have always thought it would be in relation to art museums, therefore the move to the science museums has opened a whole new world of experiences and opportunities. I have discovered how (and how much) science matters for every aspect of our lives and how important education is in creating consciousness, knowledge and a critical stance for each individual.

2 To help create the conditions for each individual to become a science citizen and to acquire the knowledge and competences that encourage active participation in the science debate.

3 I hope every student will have the chance to say "Science is for me".



VALERIA CAPPA

GUEST #3

People should understand that science plays a big part in everyday life...

Milan, Italy

Editorial Director of Math & Science Area, Pearson Italy

After a degree in Physics and two years spent at scientific research institutes such as CERN and CSELT, she started working as a high-school teacher.
At the same time she collaborated as a consultant with several publishing companies focused on education.
In 1997, she was hired by Paravia, a historic publishing company specialised in education.
She started off as an editor of scientific books, and later took on several other roles. At Pearson she is now head of the Math & Science area, K6-13 departement.

?

1. **When did you realise you wanted to pursue a career in STEM?**
2. **What is the most important aspect in STEM education for young people among your present agenda?**
3. **In your opinion, what are the most desirable changes to STEM education in the nearest future?**

1. I have always been into science since I was very young. After secondary school, I attended a scientific lyceum and went on to study Physics at university. I landed a job in publishing almost by chance. While working as a substitute teacher, I got a second job as copy editor: I was really thrilled about both.

2. The belief that scientific subjects are difficult to study and understand is just a cliché. We should stress how beautiful it is to discover and understand the world around us. Plus, we should use curiosity and discovery as keywords to draw kids and teenagers to science.
People should understand that science plays a big part in everyday life and does not only affect scientists in their labs.

3. I would love to see scientists in classrooms and students in labs!

BRUNA MARINI

GUEST #4

STEM education should allow boys and girls to explore new fields and think outside the box...

Trieste, Italy

Co-founder and Project Manager, Ulisse BioMed, AREA Science Park

Bruna Marini was awarded her PhD in Molecular Biology by the Scuola Normale Superiore (Pisa) for her research performed at the Molecular Medicine Lab of ICGEB (Trieste).

Her PhD thesis, focused on the study of the influence of nuclear architecture on HIV integration, was published in the prestigious Nature journal.

After her PhD, together with her colleague Rudy Ippodrino, she decided to found Ulisse BioMed to start her own career in applied research. She believes that scientific discoveries need to be efficiently translated into the health and wellbeing of the people.

?

1. **When did you realise you wanted to pursue a career in STEM?**
2. **What is the most important aspect in STEM education for young people among your present agenda?**
3. **In your opinion, what are the most desirable changes to STEM education in the nearest future?**

1. I had the chance to attend a double diploma between Trieste and Paris, and I could see completely different approaches to STEM education. The merge between the two approaches allowed me to understand that I wanted to put myself on the test, starting a PhD project. The years of lab experiments on the bench made me realise that I wanted to exploit my knowledge and expertise to develop solutions and ideas able to solve issues and have a direct impact on people's life.

2. It is important to be prepared but also prone to learn new things and open-minded. STEM education should provide knowledge to young boys and girls but also allow them to explore new fields and think out of the box.
STEM education should offer multiple academic lab experiences, short work experiences inside companies, opportunities to attend international conferences and workshops, opportunities to get involved in different fields of expertise, not only scientific ones. STEM educators should allow young boys and girls to express their ideas, discuss with them, and give them opportunities to try their hypothesis.

3. STEM education should provide opportunities and support innovation.

7 MODULES TO MAKE STEM EDUCATION ATTRACTIVE: CHALLENGES, IMPACT AND CAREER PERSPECTIVES.

- MATHEMATICS
- PHYSICS
- ASTRONOMY
- CHEMISTRY
- ENGINEERING
- MEDICINE
- CITIZEN SCIENCE

STEM4youth is a result of the cooperation and joint research efforts of **10 European organisations** having extensive experience in science education and promotion..
The project's ultimate ambition is to **develop educational contents** and to **make science education and scientific careers more attractive** for young people.
The project seeks to produce a comprehensive, multidisciplinary series of educational content – i.e. courses presenting the key topics of STEM disciplines to young people as integrations to their formal and informal education (extracurricular activities, science festivals, university lectures and open, web-accessible materials for self-study).

The content is organised around **7 STEM disciplines**:

Mathematics, Physics, Astronomy, Chemistry, Engineering, Medicine and Citizen Science.

For each discipline 7-9 challenges (1- or 2-hour lessons / lectures / demonstrations / hands-on activities) are being developed, which were identified as the most important to boost creativity, competitiveness and spirit of innovation.
The challenges will be mostly presented through their practical applications and their impact on our everyday life and work. A range of formal and informal methodologies and tools are being employed to **present the scientific challenges in an attractive way** (learning by experiment, gaming, citizen science at schools). They will be accompanied by a presentation of the skills and competences developed by STEM education and how these skills address the current and future European labour market needs.

STEM4youth presents how the abovementioned general ideas could be practically implemented in STEM education proposing how to harmonize educational content from different areas, how to structure the courses and finally **how to provide practical guidelines for teachers** to help them to conduct multidisciplinary lessons in a responsive, interactive manner.

METHODOLOGICAL APPROACH. WHAT KIND OF COMMON MATRIX DID WE FOLLOW TO CREATE THE MODULES?

?

Inštitut Za Razvojne In Strateške Analize (IRSA) elaborated the instructional matrix for learning tools and methodologies for STEM-related disciplines which were evaluated by domain experts. These are related to real world applications, interaction and social media, as opposed to the often theory-centred and abstract STEM subjects.

Furthermore, in collaboration with the project consortium, IRSA developed the exploitation plan and market strategy which are part of project dissemination activities. It includes the promotion strategy of the STEM educational products as well as the potential of its most distinctive output – the OCLMS platform.

MATHEMATICS

Developed by **Technická Univerzita Ostrava (VSB), Czech Republic**

WHY INCREASING INTEREST IN MATHEMATICS AMONG YOUNG PEOPLE? BECAUSE **MATH IS A SILVER THREAD IN YOUR EVERYDAY LIFE**.

Certain qualities that are nurtured by mathematics are power of reasoning, creativity, abstract or spatial thinking, critical thinking and problem solving.

The courses were designed to expand/develop the scientific knowledge of teachers and students by gamification, using attractive graphics and immediate evaluation.
The aim is to increase interest in mathematics among young people.
Mathematics is a methodical application of matter.
Among the qualities nurtured by mathematics are power of reasoning, creativity, abstract or spatial thinking, critical thinking and problem solving. To achieve these aims the VSB project team has designed interactive tests and games for high-school students and teachers to be used either in class or at home, with significant benefits.
The main advantage is their immediate evaluation, attractive graphics and uniform system of navigation. **The entire set composed of hundreds materials covers all topics of secondary school mathematics**. Tests and games can be used on interactive whiteboards or computers as well.

The Technická Univerzita Ostrava project team has developed interactive PDFs, supplementary materials, guide videos and teachers' guides for 13 following math topics and 7 different challenges.

OUR METHODOLOGIES

- Learning by playing *Educational games*
- Multimedia

OUR ACTIVITIES

- ANALYTIC GEOMETRY
- BASICS OF MATH
- COMPLEX NUMBERS
- DIFFERENTIAL CALCULUS
- EQUATIONS AND INEQUALITIES
- EXPONENTS AND LOGARITHMS
- FUNCTIONS
- GEOMETRY
- INTEGRAL CALCULUS
- SEQUENCES AND SERIES
- TRIANGLE TRIGONOMETRY
- TRIGONOMETRY
- COMBINATORY, PROBABILITY AND STATISTICS

OUR CHALLENGES

- FRACTAL GEOMETRY
- CATASTROPHES AND THEIR MATHEMATICAL BACKGROUND
- CRYPTOLOGY
- BIG DATA
- STATISTICS
- DETERMINISTIC CHAOS
- LIMES COMPUTIBILITATIS

were developed as popularising interactive lecture presentations including teachers' guides.
The topics were specifically chosen by university lecturers based on Employment Labour Market Trends in EU.

!

The Mathematics Module is available at:
https://olcms.stem4youth.pl/discipline/mathematics

PHYSICS

Developed by **Politechnika Warsawska, Poland**

THE PURPOSE OF PHYSICS IS TO UNDERSTAND THE LAWS OF NATURE. IT CAN BE AN EXCITING COMMITMENT IF WE THINK THAT OUR LABORATORY IS AS BIG AS THE ENTIRE UNIVERSE.

Politechnika Warsawska's team created seven sub-courses on Physics key-topic subjects - with teachers' guides, supplementary materials, practical experiments, remote experiments and guide videos.

OUR METHODOLOGIES

- Learning through experiment
- Hands-on activities
- Inquiry-based learning
- Multimedia

OUR ACTIVITIES

ATOMIC NUCLEUS AND RADIOACTIVITY
- Gamma radiation attenuation experiment
- Geiger counter - remote experiment

OPTICS AND OPTICAL FIBERS
- Snellius experiment

HOLOGRAPHY NEW MATERIALS (NANOMATERIALS)
- Hall effect experiment

PHOTOVOLTAICS
- Photoelectric effect - remote experiment
- Black body radiation - remote experiment

MICROWAVES AND THEIR APPLICATIONS
- Michelson interferometer experiment
- Doppler effect experiment

DYNAMICS OF COMPLEX SYSTEMS

"Our modern culture is based on physics", said one physicist and he was right if you think about social changes of the past decades. Internet? Each of us is connected to more people and sustain more relationships than our ancestors could have done throughout their lives. Mobile phones? Bunch of devices like camera, GPS, accelerometers in one pocket?

Each of us owns more computing power in his hands than NASA with all its budget when launching Saturn V off the Earth. And how much do we understand of the physics behind this phenomena?

If you want to be an aware user and also to shape these technologies and create new ones, **Physics is here to help you making it real**.

POLITECHNIKA WARSAWSKA HAS DEVELOPED A COURSE IN PHYSICS THAT EXPLORES THE INFINITE APPLICATIONS OF THIS DISCIPLINE.

Maybe you are fascinated by rocket science, launching satellites and processing data? With the "Artificial Satellites And The Modern Professions" activity you can construct your own basic electrical circuits, process images from space missions and understand the physics behind space exploration.

Just like everybody else, you surf the Internet on a daily basis. How does it get to your computer? The "Optics and optical fibres" module will immerse you into modern telecommunication technology.

Aren't you stunned by the amount of electronics devices in a hospital? In medical physics we use ionising radiation to cure cancer. With "Atomic nucleus and radioactivity" you can learn what radioactivity is and how we diagnose and treat people with radiation.

The great progress of the technology of our century is due in large part to physics.

When the weather is hot, you immediately think of global warming. Burning fossil fuels kills us by many ways so it is useful that physicists are working hard to get rid of them: in "Photovoltaics" you learn **how solar cells operate and what to expect in the future**.

You will have certainly heard about 3D printing. If you want to **do something interesting with a 3D printer**, than "Science in 3D – Astrolabe" is the right guide for you.

NEXT TIME YOU LEAVE A CROWDED TRAIN OR TAKE A NARROW EXIT FROM SCHOOL OR A PLANE, REMBER THAT SCIENTISTS CAN MAKE IT BETTER THANKS TO CROWD DYNAMICS.
AND SO CAN YOU!

!

The Physics Module is available at:
https://olcms.stem4youth.pl/discipline/physics

ASTRONOMY

Developed by **Research Paths, Greece**

FROM THE AEROSPACE INDUSTRY TO TELECOMMUNICATIONS
UP TO SATELLITE IMAGE PROCESSING.
ASTRONOMY IS CLOSER THAN YOU THINK.

Research Paths has developed ten lessons having as subjects several aspect of cosmos. The astronomy lessons consisting of teacher guides, presentations, worksheets, evaluation sheets and many more.

OUR METHODOLOGIES

- History and storytelling
- Learning through experiment *Simulation*
- Multimedia

OUR ACTIVITIES

COURSE
CONSISTING OF 10 LESSONS

- The universe.
- Our solar system.
- Travels in space.
- The sun.
- The greenhouse effect and climate change in planets and its satellites
- The use of satellites by humans and modern space related professions.
- The contribution of Astronomy and Astrophysics in the development of science.
- Understanding our universe and modelling celestial phenomena.

Astronomy and Space Science have highly contributed to other scientific fields and have a significant impact on our social lives.

Among their applications are calendars, industrial products, aerospace technology, satellite imaging, telecommunications, mapping and global navigation. Astronomy has strong connections with STEM and the human sciences' disciplines as well. This view is corroborated by the Strategic Plan for Astronomy of International Astronomical Union where science and space research are approached in an interdisciplinary way (IAU, 2009).

In the context of this project, Research Paths has developed an astronomy course consisting of **ten lessons**.

The instructional objectives for each lesson were determined after taking into consideration **the astronomical content of the lesson**, t**he scientific processes involved** and **students' misconceptions** on each subject and the nature of science.

It is important to consider students' misconceptions on astronomy.
The aim of the module is to look at astronomy from a new point of view.

The teaching tools and materials used in the course are: storytelling videos, audio-visual material, digital simulations, videos, images, hands-on activities based on constructions with simple materials (e.g. Telescope, a greenhouse-like construction, Robotic hand), drones (with Arduino based sensors onboard), worksheets, scenarios, presentations and evaluation sheet.

!

The Astronomy Module is available at:
https://olcms.stem4youth.pl/discipline/astronomy

CHEMISTRY

Developed by **Inštitut Jožef Stefan, Slovenia**

CHEMISTRY CONDITIONS AND DETERMINES
THE CHARACTERISTICS OF THE MATERIAL WORLD,
MAKING IT THE WAY WE ARE USED TO KNOW IT.

We can find chemistry in our daily life in the food we eat, the air we breathe, chemicals we use, our environment, health, emotions, and literally every object we can see or touch.

Chemistry is known to be one of the earliest scientific disciplines and, as such, has its **origins in the basic observation of the natural world**. Chemical reactions, ranging from invisible to colourful, from unnoticeable to explosive, have captured the imagination of students everywhere since the inception of education. Chemistry therefore represents a subject choice that is not only attractive in its own right, but also has a never-ending potential for variety and improvement. **It is also a very visual subject that quickly attracts the young mind**.

To introduce Chemistry at school, JSI prepared nine chemistry programmes, covering chemistry in everyday areas, namely nanotechnology, computing, environment, transport, medicine, sport, agriculture, recycling, and manufacturing. Programmes included **theoretical background**, materials needed for the **implementation of the experiment**, a description of the experiment, and **questions for students** to check their knowledge.

Inštitut Jožef Stefan developed nine worksheets for the implementation of Chemistry experiments. Videos were also prepared for an illustrative demonstration.

OUR METHODOLOGIES

- Learning through experiment
- Hands-on activities
- Multimedia

OUR ACTIVITIES

- CHEMISTRY IN NANOTECHNOLOGY
- CHEMISTRY IN COMPUTING
- ENERGY AND ENVIRONMENT
- CHEMISTRY IN TRANSPORTATION
- CHEMISTRY AND MEDICINE
- CHEMISTRY AND SPORT
- CHEMISTRY AND AGRICULTURE
- RECYCLING
- CHEMISTRY IN MANUFACTURING

Chemistry is a very visual subject that quickly attracts the young mind.

For the implementation of Chemistry programmes Inštitut Jožef Stefan used the **learning - via experiments approach.**
It is important for students not only to get theoretical background of the topic, but also to gain practical experience.

EXPERIMENTS WERE PRACTICALLY ORIENTED AND RELATED TO EVERYDAY LIFE.
Most programmes contained materials used in everyday life, such as sunscreen, alu-foil, salt, baking soda, toothpaste, etc. Both students and teachers found the programmes to be beneficial, educational and fun.

!

The Chemistry Module is available at:
https://olcms.stem4youth.pl/discipline/chemistry

ENGINEERING

Developed by **Eugenides Foundation, Greece**

ENGINEERING IS PRESENT
IN EVERY MOMENT OF OUR DAY.
IT HAS A CHARM THAT BEWITCHES!

Eugenides Foundation coordinated and developed seven new engineering challenges. As project results, EF team designed a new cycle of EDP as innovative learning methodology applied for secondary school students, adding teachers' guides and several extra materials.

OUR METHODOLOGIES

- Inquiry based learning *Engineering Design Process*
- Hands-on activities
- Multimedia

OUR ACTIVITIES

WATER ROCKETS
- How high can a model water rocket fly?

HANDHELD VACUUM CLEANER
- Can dust cleaning be fun?

HYDRAULIC ARMS. JACK IT UP!
- Lift a load using Hydraulic Arms.

FLOATING NESTS RAFT
- Ever Heard Of A Floating Bird Nest?

HYDROBOT
- Building an underwater robot.

SOLAR POWERED (B.E.A.M) BOTS
- Make your own solar powered robot to follow the sun!

OBSTACLE AVOIDING ARDUINO ROBOT
- Build and program a robotic vehicle that avoids obstacles to follow the sun!

Technology innovations transform our world, creating whole new industries and occupations.

Every job of the future will require a good understanding of science and technology. In addition, as our man-made world keeps becoming more complex, job seekers will have to develop their problem-solving skills in order to be able to address unexpected situations. Therefore, young students should gain and hone such skills as early as possible in their lives and get ready for a fascinating but equally challenging future.

With respect to this, seven engineering challenges have been developed by Eugenides Foundation's science and technology center specialists for secondary students. Students - working in small groups - follow a 6-step design process using engineering principles to solve a practical problem.

Students were asked to find a solution to different engineering problems using the specific steps of the engineering design process.

IDENTIFY MAIN PROBLEM → **DIVIDE** INTO SUB-PROBLEMS → **EXPLORE** THE SCIENCE →

DESIGN → BUILD → TEST → IMPROVE → DESIGN

SOLVE SUB-PROBLEMS

↓

COMBINE SUB-SOLUTIONS, **TEST AND IMPROVE** YOUR FINAL DESIGN

↓

PRESENT FINAL SOLUTIONS

INTRODUCING THE ENGINEERING DESIGN PROCESS

When engineers solve a problem, their first solution is rarely their best. Instead, **they try different ideas**, **learn from mistakes and try again**.

The series of steps that engineers follow when they are trying to solve a problem they are facing and to arrive at a solution is called the **Engineering Design Process** (EDP).

!

The Engineering Module is available at:
https://olcms.stem4youth.pl/discipline/engineering

MEDICINE

Developed by **Fondazione Umberto Veronesi, Italy**

WE LIVE LONGER, AND WE GET OLDER AND OLDER.
BUT **WHAT CAN WE DO TO ALSO HAVE A HEALTHIER, BETTER LIFE?**

Medicine is a cutting-edge and pressing topic for every one of us mixing new techniques, new treatments and raising several ethical questions on how managing your own health.

In our materials, we aimed at conveying this complex scenario by describing several cutting-edge technologies (e.g. gene editing) that give rise to whole new promising yet controversial horizons.

This new way of doing medicine has made blooming professions possible in medical practice, which does only include doctors and nurses anymore, but also data analysts, cultural mediators, biotechnologists, bioinformaticians and medicine communicators.

Moreover, we have also gained **a glimpse of the technology behind medicine**: what are next generation sequencing and bioinformatics, and how can we learn these technologies? What does Big Data analysis mean in practice? What IT skills are needed to perform it? Which areas of the medical labour market require them?

Finally, **we have also focused on the ethical dimension of medical practice**: how are all the DNA data stored? Who have access to such private and fundamental individual information? How far can we go with genome editing? As young men and women, future scientists, medical professionals and, most of all, citizens, we should all reflect on these very important questions. that we should all think about.

Fondazione Umberto Veronesi produced six Medicine modules, describing the new frontiers of biomedicine using a combination of role plays, decision games, moral dilemmas, teachers' guides and toolkits.

OUR METHODOLOGIES

- Learning through experiment
- Learning by playing *Educational games*

OUR ACTIVITIES

- BIG DATA AND YOU
- GENDER MEDICINE
- PRECISION MEDICINE
- DNA EPIGENETICS AND PREVENTION
- GENOME EDITING
- BIOETHICS

All contents related to Medicine modules do not simply summarise traditional teachings of human physiology and pathology: they rather focus on the newest medical fields opened up by the genomics era.

We have kept in mind the importance of challenging students with all the ethical, societal and gender-related dilemmas and opportunities provided by these innovative scenarios.
Far from being just a mere repository of textbook notions about human body, these materials have been tailored to make students aware that **the medical field is now reaching a critical turning point** in which scientists could really change someone's genome as desired, and that the direction the future research and legislation will take is also in their hands.

!

The Medicine Module is available at:
https://olcms.stem4youth.pl/discipline/medicine

CITIZEN SCIENCE

Developed by **Universitat de Barcelona, Spain**

OUR METHODOLOGIES

OUR AIM WAS TO INTRODUCE CITIZEN SCIENCE AT SCHOOL AS A NEW AND INNOVATIVE METHODOLOGY FOR STEM EDUCATION.

IN A FIRST PHASE, CITIZEN SCIENCE RESEARCH PROJECTS HAVE BEEN COLLABORATIVELY DESIGNED WITH THE STUDENTS THROUGH A CO-CREATION PROCESS.

SCIENCE IS A COMMON GOOD. WE CAN ALL TAKE PART IN A SCIENTIFIC PROJECT TO BRING ABOUT POSITIVE CHANGE IN OUR SOCIETY AND IN OUR WAY OF LIFE.

Citizen Science is defined as general public engagement in scientific research activities when citizens actively contribute to science, either with their intellectual effort or surrounding knowledge or with their tools and resources.

It has been well documented that the introduction of Citizen Science at school can have many positive outcomes, such as increasing students' participation and motivation for STEM learning.

Citizen science has a strong potential to give new readings and new opportunities for approaching environmental and social issues, in a choral key.

Students of secondary schools from Barcelona, Athens and the Warsaw region co-designed experiments devoted to foster local social change.

Issues such as gender violence, social inequalities, mobility, the value of public space or costal water pollution were at the core of this collective work.

This face-to-face work allowed us to test and improve a Citizen Science Toolkit for teachers that will soon released. Thanks to this open resource, teachers will be able to include the co-creation of Citizen Science projects in the classroom, as well as to have access to a list of ready-to-use Citizen Science projects, classified by STEM disciplines.

!

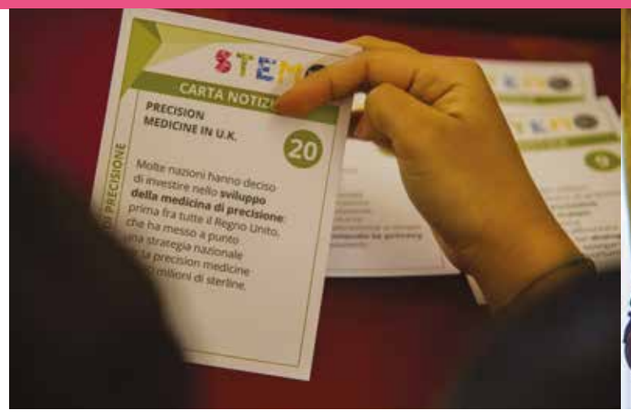
The Citizen Science Module is available at:
https://olcms.stem4youth.pl/discipline/citizen-science

DISSEMINATION EVENTS

The STEM4youth project was presented in several workshops, seminars, conferences and scholar events across Europe.

OVER
70 EVENTS › in the last **2** YEARS

THE STEM4YOUTH MID-TERM CONFERENCE, ORGANISED DURING THE #STEMINTHECITY FESTIVAL PROMOTED BY THE MUNICIPALITY OF MILAN IN APRIL 2018, WAS ONE OF THE MAJOR DISSEMINATION EVENTS.



TRIAL AND OUTREACH ACTIVITIES

AIMS OF THE TRIALS

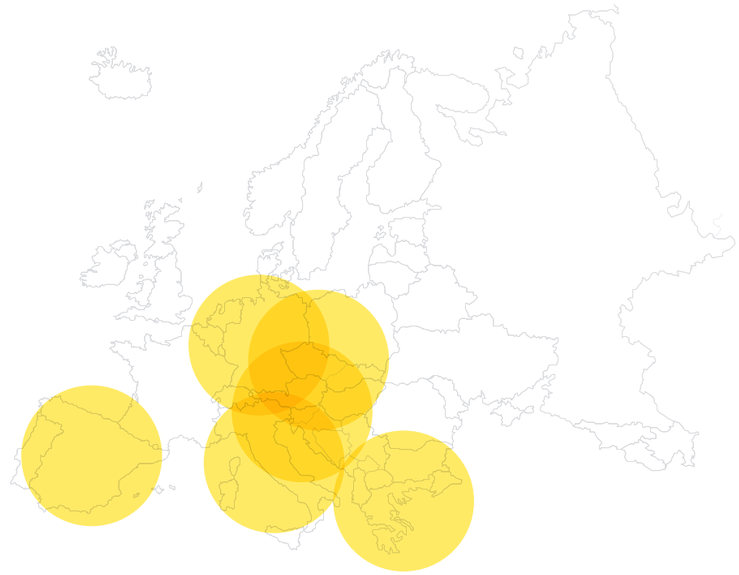
- **TESTING** THE PREPARED PROGRAMMES
- **COLLECTING** FEEDBACK FROM STUDENTS, TEACHERS AND RESEARCHERS
- **ASKING** STUDENTS TO COMPLETE AN APTITUDE TEST
- **PRODUCING** NEW CONTENTS AND UPDATING EXISTING ONES
- **SUMMING UP** THE TRIALS AND DISCUSSING PRELIMINARY OBSERVATION

STARTING DATE > OCTOBER **2017**

ENDING DATE > JUNE **2018**

COUNTRIES INVOLVED

- POLAND
- GREECE
- SLOVENIA
- ITALY
- CZECH REPUBLIC
- SPAIN



TOTAL PARTICIPANTS

68 SCHOOLS INVOLVED

120 TEACHERS INVOLVED

2,056 STUDENTS PARTICIPATING IN CLASS TRIALS

TRIAL RESULTS AND ROADMAP FOR THE FUTURE OF STEM EDUCATION

The STEM4youth project has designed a large number of STEM activities related to seven main disciplines: Mathematics, Physics, Astronomy, Chemistry, Engineering, Medicine and Citizen Science.

These activities have been designed following a variety of learning approaches including inquiry-based learning, learning through experiment and hands-on learning.

https://olcms.stem4youth.pl/discipline

The reliability and effectiveness of these activities have been tested, with more than 2,000 high school students and 120 teachers from 6 countries: **Poland, Czech Republic, Slovenia, Greece, Spain and Italy**.

THE RESULTS HAVE SHOWN THAT, AFTER COMPLETING THE ACTIVITIES:

Students reinforced previous knowledge and acquired new one. For example, a Czech student stressed during the interviews "I have learnt Maths through enjoyable lectures". A Spanish student stated "STEM4youth activities also help us remember concepts that we learnt in the past".

Students increased their motivation for learning, developing key competences such as critical thinking, sense of initiative and entrepreneurship. In particular, they enjoyed the design and construction of real challenges, manipulating physical materials, further beyond their standard curricula.
A Polish student stressed "The activities motivated me to learn Physics", and a Greek student stated "It has been very stimulating to use daily life objects to carry out the experiments".

Students increased their awareness about the importance of STEM disciplines and their applicability in everyday life. Students especially enjoyed working under the Engineering Design Process (EDP) methodology.
In particular, they reported that applying the theoretical concepts learnt during the school lessons to obtain a final product was a very satisfactory experience. For instance, a Spanish student stressed "It was really rewarding and enriching to construct the floating nest with the concepts learnt at school and actually place the nest on the lake for the birds".

Students increased their collaborative work competences and communication skills. The richness of these activities and the learning methodologies proposed foster the promotion of a learning community, where students and teachers interact developing learning and research skills as well as social and civic competences.
A Slovene student stressed "it was really nice collaborating with other students in the resolution of the activities". An Italian student stated "we learnt a lot from the discussions with other classmates and teacher during development of the activities. A Greek teacher stated "The activities promoted the sense of cooperation between students and teachers".

!

When implementing STEM4youth activities, teachers should allow students to lead the activities, acting simply as advisors and facilitators.

They should let students search for information, explore and experiment new concepts as well as develop their own ideas.
Teachers should also consider the number of students participating in each activity to equally share the workload and estimate the time and resources needed. After implementing the activities, teachers should participate in events where students present their activities to reinforce the knowledge acquired.

STEM FOR YOUTH

ENJOY. SCIENCE TECHNOLOGY ENGINEERING MATHEMATICS.

THE FUN IS NOT OVER!

FOLLOW ALL THE UPDATES ON
www.stem4youth.eu

AND STAY WITH US ON

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Fondazione Umberto Veronesi – per il progresso delle scienze

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RESEARCH PATHS RESEARCH EDUCATION CULTURE

VŠB Technická univerzita Ostrava 1849

Universitat de Barcelona

UC Universidad de Cantabria

OPEN EVIDENCE

IRSA Institut za razvojne in strateške analize

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