MAKING STEM EDUCATION ATTRACTIVE FOR YOUNG PEOPLE BY PRESENTING KEY SCIENTIFIC CHALLENGES AND THEIR IMPACT ON OUR LIFE AND CAREER PERSPECTIVES

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Abstract

This article presents an approach to STEM education for secondary and high school students proposed by currently ongoing STEM4youth project (SWAFT, H2020, www.stem4youth.eu). The approach is a result of cooperation and a joint research of 10 European organizations, having deep expertise in science education and science promotion. The ultimate project ambition is to develop educational content and teaching scenarios which in effect will make science education and scientific career more attractive for young peoples. To meet this goal, the project places the STEM education in a broader societal and economy context claiming that education should primarily response to the labor market demands and address concrete societal challenges not directly associated with science. The project seeks to produce a comprehensive, multidisciplinary series of educational content - courses presenting key STEM disciplines' topics to support young people formal and informal education (extra-curriculum activities, science festivals, university organized lectures and open, web-accessible self-study materials). The content is organized around 6 STEM disciplines: Mathematics, Physics, Astronomy, Chemistry, Engineering and Medicine. For each discipline 7-9 challenges (1-2 hours lessons/lectures/ demonstrations / hands-on activities) are being developed, which were identified as the most important to boost the creativity, competitiveness and innovativeness. The challenges will be largely 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) Also it will be shown which specific skills and competence STEM education develops and how these skills address the current and future European labour market needs. In the effect, the project provides a helicopter view of STEM disciplines and job characteristics associated with these disciplines to help young people in taking conscious decisions on their future (a subject of interest, field of study and finally career path to pursue). The article 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.

Keywords: STEM, learning methodologies and tools, citizen science.

1 INTRODUCTION

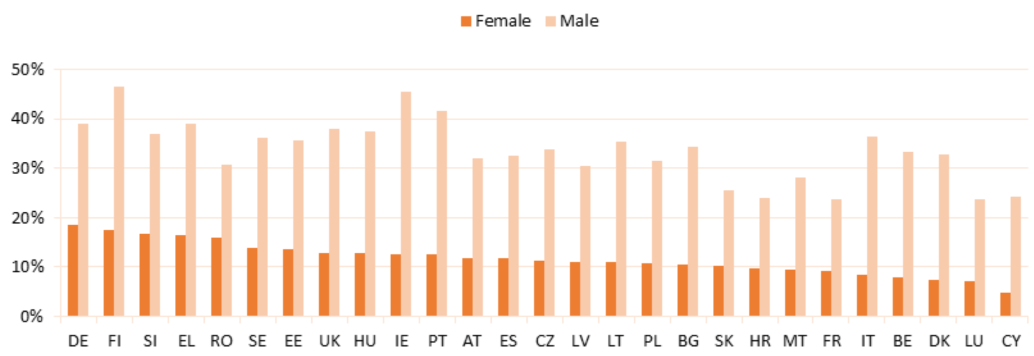
1.1 Problem to be addressed

Over the next ten years, STEM employment in Europe is projected to rise: 8.2 million new openings for STEM skills are expected to be created[1]. However, little is known as to whether there will be enough students and young graduates to match this rising demand. Although STEM students account for one-fourth of the student body, some might change faculty or drop out before completion. Furthermore, STEM programs are consistently less popular among women. An imbalance on the labor market regarding supply and demand for STEM-skilled specialists might create a problem for the Europe economy. Also, education profiles of STEM graduates do not always correspond to the employee expectations.

1.2 STEM labor market in Europe

With regards to the supply of STEM skills, the EU-28 there were 5.3 million STEM students in 2014, of which 68.9% were male (about 3.6 million) and 31.1% were female (about 1.7 million) according to Eurostat data. STEM students account for about 27.2% of all students in tertiary education. Germany, the most populous Member State in the EU, in 2014 had 954,363 students enrolled in a STEM degree, which was the highest number in the EU in 2014. The United Kingdom (604,837 students), France (429,421), Spain (429,114) Poland (355,963) and Italy (305,127) had the next largest STEM population. Germany also had the relative largest of STEM students, corresponding to 32.8% of all students in tertiary education. Greece (28.1%), Romania (28.0%), Finland (27.9%) and the United Kingdom (25.7%) had the next largest STEM student population.
STEM programs are consistently less popular among women. Nowhere in the EU are STEM programs attended by more than one-fifth of the female student population. They are relatively more attractive in Germany, where around 18.5% of female students are enrolled in a STEM program - while male STEM students account for around 38.9% of all students. In Italy, France, Belgium, Denmark, Croatia, Luxembourg, Cyprus, and Malta, less than 10% of female students are enrolled in a STEM program. Conversely, male STEM students account for more than 40% of the student body in Portugal, Ireland and Finland.

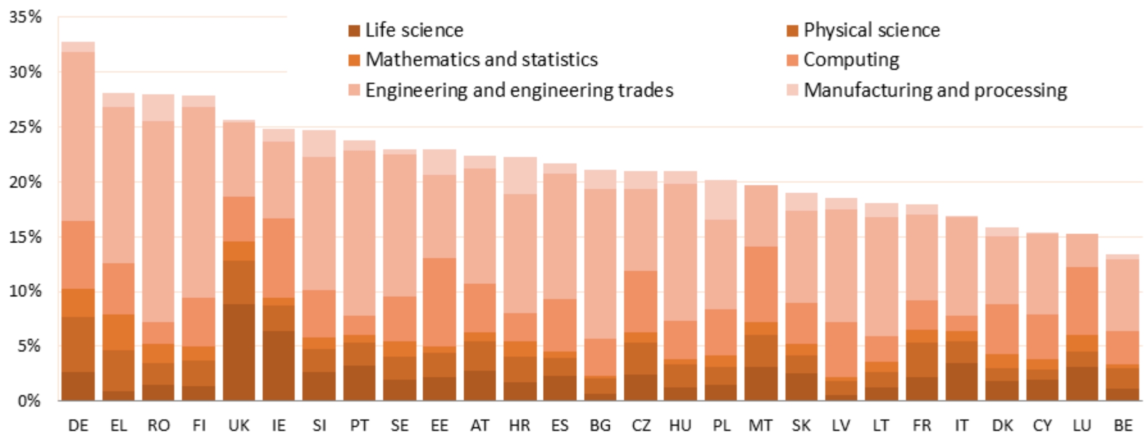
Figure 1 STEM students as % of student body in the EU by gender, 2014



Source: Authors' elaboration on Eurostat data (educ_uoe_enrt).

Engineering accounts for almost half of the STEM student population. Across the EU, almost half (46.0%) of all STEM students, around 2.0 million, were studying engineering and engineering trades, with almost four in five students (81.8%) being male in this field of education. The second most common field of education (around 750,000 students) was computing, including computer use and computer science programs, which accounted for 17.4% of the STEM student body. In this field, 82.8% of the students were male.
The STEM student supply across the EU is highly varied. Among the EU Member States, some STEM fields can be spotted in which — compared with all fields of study— a particularly large or small share of students was enrolled in 2014. The share of Life Science students was relatively low in Latvia and Bulgaria, while it was particularly high in the United Kingdom and Ireland. The share of Physical Science students was relatively low in Cyprus, Latvia, Lithuania, and Denmark, while it was relatively high in the United Kingdom, Germany, and Greece. Similarly, the proportion of students in Mathematics and statistics was particularly high in Germany and Greece and relatively low in Bulgaria and Belgium. The share of Computer Science students was relatively low in Italy and Portugal and relatively high in Estonia and Ireland. The share of engineering students was relatively low in Denmark and Luxembourg and relatively high in Romania and Finland. Finally, the proportion of Manufacturing and processing students was negligible in Italy and the United Kingdom, virtually non-existent in Luxembourg and Malta, and relatively high in Poland and Croatia.

Figure 2 STEM students as % of total students in the EU, breakdown by field of study, 2014



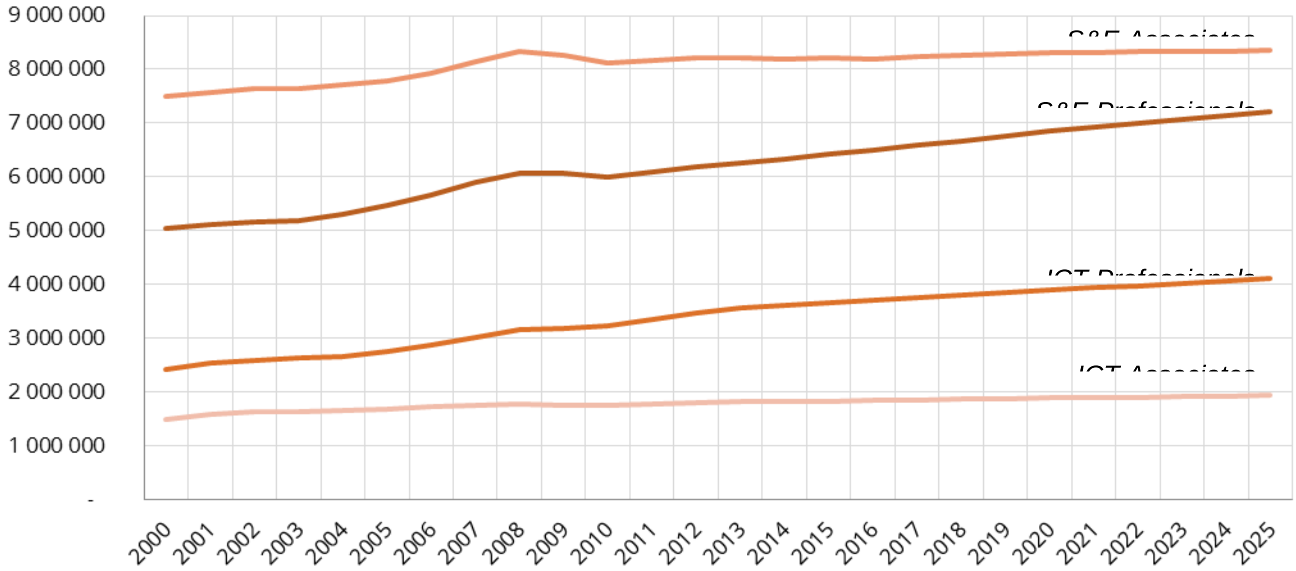
Source: Authors' elaboration on Eurostat data (educ_uoe_enrt).
Note: Missing observation for the Netherlands

With regards to the demand for STEM skills, in 2015, STEM employment accounted for 9.0% of the total employment in the EU. STEM employment is here defined as the sum of employment in the following four statistical categories: Science and engineering (S&E) professionals[2] ; ICT professionals[3] ; S&E associate professionals[4] ; ICT associate professionals[5] . The total employment in the four STEM occupations reached 19,920,096 according to data from the European Centre for the Development of Vocational Training (CEDEFOP). The figure includes around 7.8 million science and engineering (S&E) associate professionals (including physical and engineering science technicians, construction supervisors, power plant operators, process control technicians, ship and aircraft controllers, about 39.4% of total STEM occupations), followed by around 6.7 million S&E professionals (including physicists, mathematicians, life science professionals and engineers about 33.7% of total STEM occupations), around 3.7 million ICT professionals (including software developers and database professionals, 18.4% of total STEM occupations), and around 1.7 million ICT technicians (about 8.6% of total STEM occupations).

During the period 2011-2015, STEM employment in the EU has increased by 4.6%. The change is mostly due to the increase in ICT professionals (+16.4%) and ICT associate professionals (+10.0%). The number of people employed as S&E professionals has increased by 4.1%, whereas employment of S&E associate professionals has slightly decreased (-0.8%) during the period 2011-2015.

The positive trend is expected to continue. In the period 2015-2025, there will be 8.2 million new STEM jobs in the EU. The figure, based on CEDEFOP data, amounts to the number of people who will be required to work in one of the four STEM occupations, given projected changes in employment and replacement demands. Each of the four STEM occupations is expected to have a positive employment balance.

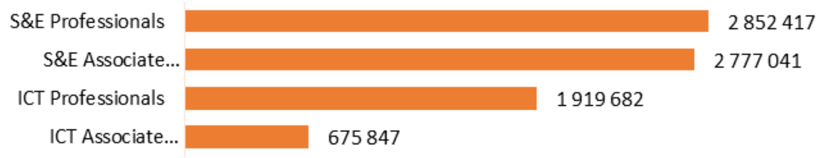
Figure 3 Future STEM employment, absolute numbers



Source: Authors' elaboration on CEDEFOP data

According to CEDEFOP, by 2025 employment for S&E and ICT professionals is projected to increase by 12.5% and 11.8% respectively, which means around 2.9 and 1.9 million job openings including replacement demands. To a lesser extent, projected change in employment to 2025 for S&E and ICT associate professionals amounts to 1.9% and 5.2% respectively, which translates to around 2.7 and around 0.7 million job openings including replacement demands.

Figure 4 STEM job openings in the EU, 2015-2025



On the other hand, little is known about future growth of STEM supply, and whether there will be enough STEM students and graduates in the EU to match the rising demand.

1.3 Major reasons responsible for low popularity of STEM education and STEM carriers.

- An increasing skepticism and criticism in the perception of science and technology, "In particular, a need to 'humanize' school science, to show that science is part of human history and culture and that it is a corner stone in our present, modern world view (…) as well as well as a basic element of many jobs and occupations"[6]
- The way the STEM is taught especially on undergraduate level - a mismatch between a demand and a supply of qualified teachers and about the gap between science education research findings and what happens in the classroom [7, 8]
- Student's perception that STEM is difficult
- Little and non-accurate information about skills needed by employers and characteristics of future jobs.
- Little involvement of stakeholders (students, families, teachers, employers and civil society) in science education policy making, research, development and innovation, and in the formal education system[9]

1.4 Factors that motivate students towards STEM

A number of in-depth interviews with secondary, high school, undergraduate students and high school teachers as well as literature studies found the following points as the most influential for attracting students to STEM.

- The early (during primarily, secondary school) interest in STEM increases chance the student will not change his orientation and will study STEM (due to early specialization of school curriculum youngster practically have to decide on their future at the age of 14-15)
- Parents and then teachers have the biggest influence on boys' and girls' STEM orientation. Highly motivated, passionate teachers seem to strongly develop the student STEM skills (young people have not developed self-learning ability yet))
- The dominate student preference is to really understand a problem, NOT only to learn a schema how to solve an exercise. STEM teaching is often dominated by a theoretical approach, while more practical activities (laboratory, hands on, experiments) are highly welcomed by students.
- Better coordination of different subjects curriculum is also required to enhance the learning process.
- Students are very open to extra schools activities: open days, lectures at a university, workshops organized by employers, meeting with psychologists (to determine their personality type) and with career advisors. Also, courses developing soft and business skills are welcomed as well.
- STEM is commonly regarded as a difficult but practical area, which could guarantee well paid jobs while social science and humanities are seen as less practical ("as teaching nothing").
- Students' motivation on their interests, future carriers is also heavily influenced by future job perspectives, but all the same students have often little and not correct ideas on how their work will look like (office work is regarded as boring and not interesting).
- Gender is still an issue, but currently is getting less and less important (partially due to the fact that new kind of study specializations and jobs are currently being creating without the historical burdens).

2 STEM4YOUTH APPROACH TO STEM EDUCATION.

In order to attract more student to STEM in STEM, the EC has granted a project STEM4youth under Science for and with Society Horizon 2020 Programme. The project consortium, coordinated by Warsaw University of technology, comprises 10 organizations from 6 European countries,. The project (May 2016 - October 2018) will produce a multidisciplinary STEM course as well as guidelines for teachers intended for formal, informal, supervised and non-supervised education. The course will comprise different tools for effective learning: multimedia, educational games, hands-on activity, a remotely-accessible laboratory. The course content and access to the course infrastructure will be provided by an open learning content management system, which will combine the content management and learning management systems features. The majority of the course content will be published under an open license, which will allow modification of existing and uploading of a new content. Teachers/users will be also able to compose their own courses using the content items available on the platform. More information about the project and the list of consortium partners is available on the project WebPage (www.stem4youth.eu) as well as on the EU Cordis Portal

2.1 Project target group

The primarily project target is a group means of young boys and girls that have not yet chosen the main subjects they want to study. The age range varies across different countries, but it usually lies between 12-15 years. In most European curricula for that age group, STEM education is central, and the young boys and girls will start to make some choices related to their future careers. This is the most important period for improving young people's views on STEM opportunities, especially for the girls. The project educational content will be presented to young people by their teachers, parents, during universities events and by providers of educational material. Furthermore, we believe the project will raise interest of employers, student communities, educational authorities and scientific community.

2.2 Project objectives

- Raise youngster interest in STEM possibly early (preferably during secondary school)
- Support student extra curriculum activity (and to provide lesson ideas for teachers)
- Inspire and attract young people to STEM by presenting the most important / promising challenges of the core STEM disciplines.
- Show the dependences between challenges and science disciplines, and an impact of an invention from one discipline on other fields and disciplines
- Improve self-learning skills (which will be very important during study and later in the adult life).
- Develop ability of group work and active participation in a lesson
- Application of different learning technologies to present challenges in the most effective and communicative ways.
- Including responsible research and innovation and social dimension in the content and the way the lesson will be conducted, as well as information about future career opportunities.
- Prepare the content in a way that is also attractive for adults (also to provide information for parents)
- Prepare the content in a manner to be exploited in different ways (open days, science festivals, self-study, additional material for teacher to be used for youngster with different background having different school curriculum)
- Support open content sharing, content creation and cooperation between students and between teachers from different countries via an open learning content management system (to be developed in the project).

2.3 Tools and methodologies employed in STEM4youth

Main tools and learning methodologies in the project are listed and shortly described below

- SOCIAL MEDIA – supports building Virtual communities thanks to web 2.0 features and is frequently used by youth
- GAMIFICATION – typically uses video game elements to improve user experience and engagement in non-game service and applications, could include learner-content, learner-instructor and learner-learner interactions
- LEARN BY PLAY AND EDUCATIONAL GAMES – is rather focusing on activity than the final product, is associated with low risk and is highly engaging. Also extends the playful qualities of players to serve the educational agenda
- MULTIMEDIA – stands for integration of multiple media elements (audio, video, graphics, text, animation, etc.) into one whole, can be used in presentation software, e-learning platforms, infographics, etc.
- HANDS-ON ACTIVITIES refers to “Learning by doing”, concentrates on resolution of real-world challenges, uses of prior knowledge to solve new problems and is oriented on interdisciplinary and self-directed learning
- INQUIRY BASED LEARNING (IBL) – creates opportunity for learners to explore collaboratively topics of personal and social interest and can be implemented as problem-solving, discovery and/or creative thinking activities. Also IBL includes several levels of inquiry (confirmation inquiry, structured inquiry, guided inquiry, open inquiry and blended inquiry)
- LEARNING VIA EXPERIMENTS refers to activities in which pupils follow guided questions in order to collect data, simulate with tools or participate in decision-making environments. Involves actively pupils in the execution, prediction, observation and recording
- CITIZEN SCIENCE – describes practices in which volunteers partner with scientists to answer and pose real-world questions. Citizen science general aims at public’s engagement in scientific research activities. Citizen science project are often ran at schools to teachers’ help - In schools, projects can be developed over a long period and with a large number of volunteers

2.4 Tools and methodologies employed in STEM4youth

For our project purposes, we have analyzed the Responsible Research and Innovation (RRI) concept[10, 11] and identified 10 ideas (listed below), which seems the most relevant to STEM education and our project content. All topics challenges presented in the course will be analyzed from the social perspective in relation to some of these ideas. Also, we will recommend the teachers an engaging discussion with students on these topics during their lessons with the STEM4youth content.

1. RRI RESHAPES WHAT TO TEACH IN STEM - STEM contents and practices should be rethought to include the RRI perspective.
2. RRI CHALLENGES THE METHODOLOGIES TO BE USED IN STEM EDUCATION - The RRI perspective is neither a STEM educational methodology nor is it promoted per se by using innovative STEM educational methodologies.
3. LEARNING RRI ASKS FOR FIRST HAND EXPERIENCES - Learning on STEM processes and about STEM from an RRI perspective implies that these ideas and competences should be experienced first-hand in teaching and learning
4. RRI NEEDS EXPLICIT AND CRITICAL REFLECTION IN STEM CLASSES - It is necessary to give room to explicit reflection on the value and limitations of RRI in learning contents about and of STEM
5. MOTIVATION IS KEY FOR RRI PRACTICE IN STEM EDUCATION - Students' motivation is a key educational element that is crucial for both RRI school practice and STEM learning. Inclusion of non-conventional learning environments, both in formal and informal education, could be used to boost initial motivation for STEM within an RRI perspective.
6. GENDER IS AN ISSUE IN STEM TEACHING - Introducing the gender perspective in the science classroom implies deep changes both in what to teach, in how to teach and in why to teach that are more profound than the mere balancing numbers or political-correctness policies.
7. INCLUSION IS A DRIVING FORCE FOR STEM LEARNING - RRI perspective asks for social inclusion and inclusion turns out to be a powerful driving force for motivating STEM learning since it better addresses shared societal challenges
8. RRI PERSPECTIVE NEEDS A SYSTEMIC APPROACH THAT OVERCOMES STEM DISCIPLINES - STEM and STEAM interdisciplinary/multi-disciplinary (merging STEM disciplines among themselves and with the arts and humanities) are particularly rich scenarios to introduce the RRI perspective with an emphasis on its systemic nature.
9. TRANSPARENCY AND OPENNESS SHOULD BE THE NEW CULTURES IN STEM EDUCATION - Reflecting with students on the importance of Open Access of our research production to promote a culture of knowledge sharing and co-construction.
10. RRI STEM EDUCATION MUST DEAL WITH UNCERTAINTY AS PART OF OUR FUTURE STEM - Education should prepare students to face changing circumstances, new insights and diverse values when promoting their responsiveness and capacity for adaptive changes required in RRI processes.

2.5 STEM4youth course general features

The multimedia learning material to be developed in the project will have the following characteristics

- informative, multidisciplinary STEM educational materials – a kind of comprehensive, introductory university STEM course
- covers the most popular STEM disciplines (mathematics, physics, chemistry, engineering, astronomy, medicine) and citizen science
- for a given science field, presents 7-10 topics with the expected biggest current or future impact on our life and work
- provides young people a general vision of STEM treated as one interdisciplinary area with a common research methodology and logic;
- answers fundamental questions each young person faces, like: what kind of career STEM will enable for me?, which skills and qualification may I develop deciding to study STEM? how can I take advantage of STEM education even if my future work won't be directly related to STEM?
- shows relation between education, economy, societal and labor market demands.
- Be used in different setting and content: Extra-curricular school activities, Dedicated lectures at universities; Science festivals and similar occasional events; Other outreach activities.

3 EXAMPLES OF COURSE CHALLENGES AND THEIR RELATION TO OTHER DISCIPLINES AND TO RRI IDEAS.

3.1 Physics - GAMMA RADIATION ATTENUATION

Gamma radiation has many applications in the medicine and industry. Most notable being medical imaging and cancer treatment. In this module, you will learn what the gamma radiation is, what are its properties and how it is used in medicine.

Ideas how to include the RRI aspects in the module

- Start with a discussion about open problem related to the topic (for example energy generation, cancer treatment etc.) and socio-scientific dilemmas/problems related to a given topic, examples will be included in the guidelines for teachers.
- Use of learning by experiment and inquiry based learning (guided).
- Starting with topics that concern local society (medicine, nuclear power), motivation boosted by inquiry-based learning.
- Include female teachers in pilots in schools, presenting female scientist as a role models, emphasis in guidelines for teachers that it is important to avoid gender bias.
- Including schools from small towns or poor neighborhoods in the project/pilots.
- Including in the guidelines ideas for interdisciplinary/multidisciplinary approach to a given topic (for example: how to combine nuclear physic with biology, how to add arts elements etc.).
- Sharing results in open repository/platforms, discussion of importance of sharing data, licensing.

Relation to other disciplines:

Mathematics (Vectors, differential and integral calculus, equations),

Astronomy,

Engineering (Tomography is used for diagnostics),

Medicine (Gamma radiation is used in cancer diagnostics and treatment)

Connections and transferability to labor market:

- Energetics (“green” energy producing)
- Telecommunication (TV signals, satellite broadcasting)
- Radio astronomy
- Navigation (GPS)
- Military applications
- Industry (glassworks, radiographic inspection of metals, light reflectors, optical equipment, measuring temperature of metal in ironworks)
- Medicine (cancer therapy , endoscopes, blood flow velocity, ultrasonic flowmeters, contactless thermometer)

3.2 Medicine BIOETHICAL IMPLICATIONS: VILLA ORCHIDEA

In this module, we propose an intellectual experiment as a tool to discuss the main ethical aspects of medicine and research, especially when public decisions must be made not only as scientific community but as a society as a the whole. Starting from the “reasons” given by students for their choices, with the guide of the teacher, all the different moral bases of choices will be investigated, to try to reach a consensus shared as a group. The experiment can be declined in different fields of medicine such as animal research, vaccination, priority of care, end of life (including choices about euthanasia). Medicine and science gives us some instruments. Is it right to use them? How and under which circumstances?

Ideas how to include the RRI aspects in the module

- Teaching medicine cannot avoid to touch upon ethical implications of medical innovations.
- Each medical decision must be explained and defended.
- Students are themselves asked to decide how to solve a controversial issue.
- Gender and inclusion issues can be discussed by modifying the experiment accordingly and proposing appropriate case-studies.

Relation to other disciplines and challenges:

- Mathematics (Statistics and probability, bioinformatics),
- Physics (Imaging, optics, nanoparticles. Gamma radiation, Snell’s law-endoscopes, Doppler effect used in Doppler ultrasonography).
- Chemistry (Biochemistry, enzymes, interactions between macromolecules, drug design),
- Astronomy (Biological and medical experiments in absence of gravity),
- Engineering (Biomedical engineering for medical devices, high tech instruments for data analysis and biomedical research),
- Citizen Science (Decision-making process and public debate about health-related sensitive topics)

Connections and transferability to labor market:

- Logical and critical thinking
- Ability to critically evaluate information about science and health
- Ability to plan and conduct a scientific experiment
- Ability to integrate single pieces of knowledge and integrate them in a big picture
- Ability to work in transdisciplinary teams
- Basic competences for entering the science and society debate about health-related topics

3.3 Astronomy

Astronomical knowledge is vital for humans. As Plato said, we become humans as we watch the sky and try to understand what these celestial bodies are. Thus, we use the laws of physics in order to understand nature, to explain and even predict natural phenomena; we construct advanced telescopes, we conduct numerous space missions to explore universe. We explore the Cosmos because we are made of star dust.

Ideas how to include the RRI aspects in the module

- The topics of our lessons have been chosen not only for their scientific interest but also for their social impact.
- All lessons are being taught as a practice that includes inquiry as a process of explaining and arguing based on evidence.
- Hands-on activities are an integral part of our lessons.
- The promotion of critical thinking is one of the most important aim of our lessons
- All lessons are planned so as to be promoted the inclusion of non-conventional learning environments.
- All lessons are planned in accordance to the principle of gender equality.
- All lessons are planned so as to promote inclusion in the classroom irrespective of the race, gender or socio-economic background of the students.
- All lessons are planned in a way to help students to deal with research challenges and be capable and competitive in the labor market of the future.

Relation to other disciplines and challenges:

Mathematics (Theory of conic sections, Three dimensional vector analysis, Tensor calculus, Analytic geometry, conicsx)

- Physics (Optics - lens construction, Doppler effect is used to measure relative speed of distant galaxies, Planck formula is applied to measure temperature of stars and age of universe, Laws of physics Meteorology)
- Chemistry (Energy and environment, Greenhouse effect)
- Engineering (Satellites, Communication networks, GPS)
- Medicine (Biological and medical experiments in absence of gravity)

Connections and transferability to labour market:

- Data analysis, Data mining, Image processing
- Computer programming, Software development
- Engineering specializing in modern technology materials
- Econophysics, Telecommunications, Law (space legislation).

4 CONCLUSIONS

The article presents the preliminary results of the ongoing (ends Oct. 2018) STEM4yoth project, which will be still developed and tested at schools with large numbers of students. The project concentrates only on selected educational aspects, which to a large extent are similar in different European countries. The project team believes that combination of many aspects: learning methodology, social dimension and career prospects may encourage young people to get interested in STEM and STEM-enabled jobs. More information on the main project website (www.stem4youth.edu) and on the partner's organization webpages.

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[2] Workers in this occupation conduct research, improve or develop concepts, theories and operational methods, or apply scientific knowledge relating to fields such as physics, astronomy, meteorology, chemistry, geophysics, geology, biology, ecology, medicine, mathematics, architecture, engineering, design and technology. Occupations in this group include, for example, physicists, astronomers, chemists, mathematicians, actuaries and statisticians, botanists, zoologists, civil engineers, and building architects. Source: CEDEFOP, EU Skills Panorama. http://skillspanorama.cedefop.europa.eu/en

[3] Workers in this occupation conduct research, plan, design, provide advice and improve information technology systems, hardware, software and related concepts for specific applications; develop associated documentation including principles, policies and procedures; design, develop, control, maintain and support databases and other information systems to ensure optimal performance and data integrity and security. Source: CEDEFOP, EU Skills Panorama. http://skillspanorama.cedefop.europa.eu/en

[4] Workers in this occupation supervise and control technical and operational aspects of mining, manufacturing, construction and other engineering operations, and operate technical equipment (including power plants, aircrafts and ships). Other professionals are involved in studying the technological aspects of products and processes. in this group include, for example, physical and engineering science technicians, mining, manufacturing and construction supervisors, process control technicians, life science technicians or ship and aircraft controllers and technicians. Source: CEDEFOP, EU Skills Panorama.

[5] Workers in this occupation support the design, development, installation, operation, testing, and problem-solving of hardware and software. They comprise a wide set of sub-occupations that range from network system technicians to telecommunications engineering technicians. Due to the wide penetration of information and communications technologies across the economy, they work across a wide range of sectors including ICT, manufacturing, telecommunications and service sectors. Source: CEDEFOP, EU Skills Panorama. http://skillspanorama.cedefop.europa.eu/en

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