BIOS4YOU

Bio-Inspired STEM topics for engaging young generations

project number: 2019-1-DE03-KA201-060125

IO1

RESEARCH ON HOW TECHNOLOGY AND ENGINEERING BRING STEM TO LIFE AND VICEVERSA

Karlsruher Institut für Technologie

kauno technologijos universitetas

CEIPES

UNIVERSITÀ DEGLI STUDI DI PALERMO

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(Studies/analysis – Questionnaire development and survey implementation)

Young students (Z-generation) are more connected and more careful to the environment and social issues as well as to psycho-physical wellbeing, compared to "millennials". The BioS4You project aims to increase the interest of new generations in STEM subjects by introducing them to the bioinspired technologies, to both the biologically inspired engineering and the scientific innovations, new treatments, technology and processes that could make a real difference in improvement of life and environment.

In order to achieve this task, as planned in the BioS4You proposal, the first Intellectual output IO-1 has been devoted to a Research Phase aiming to clarify some aspects relevant to the project. In particular, the first phase of IO-1 has been devoted on the identification and discussion of STEM panorama, need analysis in the four countries of the project Consortium and research that supports best practice in STEM education. The analysis of teacher and student need and awareness has been conducted on the base of the available literature sources.

The second phase of IO-1 focused on the identification of "hot" topics in biotech scientific innovation which could effectively engage the young learners by increasing their interest in STEM subjects, with the final aim to establish which subjects of technological innovation are of interest to the younger learner generations and useful in making students feel an active part in building a better future. We would like to select topics that not only develop basic STEM skills but also foster students' identities as capable persons and citizens in a global, fragile, and changing world.

STEM PANORAMA

According to a study produced by the "Institution of Engineering and Technology", a lack of awareness of the advantages of STEMs (Science, Technology, Engineering and Mathematics) is generally recorded globally, with different attitudes that vary according to the level of technological growth of the environment in which students grow up. Students of developing countries, are most fascinated and confident in STEM and also have little diffident towards scientists, indeed often seen as real idols, like superheroes. On the contrary, where technologies are more pervasive, it is worthwhile, in more industrialized countries, the idea that those who work in science are more advantaged seems almost something to be avoided. This type of stereotype manifests itself already in the transition from primary to secondary school, and it is the result of negative influences both at school and after school. At school, it is given above all of the lack of correct information on career prospects and turning off any enthusiasm in the bud, combined with a difficulty of theoretical study too often not compensated by practical experience. Then, there is the persistent gender gap in the choice of studies, in fact, it is measured in a population of male students triple that of female students,

generally convinced that STEMs are not useful for their professional lives. In addition, when the choice is made following the vocation of the STEM, it is actually women who have greater conviction and consistency in the path followed than their male colleagues. However, the different attitude of women is not sufficient to avoid disparities in placement in high-tech companies and discrimination phenomena also suffered by ethnic minorities in the same contexts.

The United States, Europe, other countries of the English-speaking area and the Asian economies have assumed, even if declining it in different forms, the improvement of education in the STEM disciplines as a factor of economic development.

In Europe one of the most important initiatives is inGenious (http://www.ingenious-science.eu/web/guest;jsessionid=3783E87BEDC2ABD173BF6A7AF0403289) carried out, with European Union funds, by the European Coordinating Body for Scientific, Technological, Engineering and Mathematics Education as a joint initiative between the European Schoolnet, a network of 30 ministers of European countries, and the main industries of the Union, also to address the problem of the gap between the number of students attending STEM disciplines in Asia (20%) compared to those attending them in Europe (2%) (2011 data).

The recent Opinion of the European Commission, of June 2019 indicates in strengthening the STEAM, which consider the intersections of the sciences with the humanities and artistic disciplines, one of the sectors that can contribute to the development of European economies. The opinion contains 25 political recommendations and it should be noted that the inclusion of the arts with the scientific disciplines is a positive idea especially for countries like ours (Germany, Italy, Lithuania, Turkey), which have now lost the competition for technological innovation especially in the field of ICT, but who may still have opportunities in sectors that involve the historical and cultural heritage they possess.

Technology and Engineering Bring STEM to Life[1,2]

Projects carried out to enhance STEMs sometimes suffer from a lack of clarity on the integration of these disciplines into curricula. Thus, they can boil down to putting together parts of these disciplines that basically lead to the learning of mathematics and the sciences but ignore the learning related to technology and design (typical of engineering). In fact, what often happens when it comes to STEM at school is to subordinate some disciplines in this area to the achievement of the objectives of one or some of them, without a real integration that leads to transversal learning in the STEM areas. One of the constraints is certainly the disciplinary orientation of the teachers and the teachings as well as their organization of the work which should privilege, compared to the current one, the team activity with changes, therefore, also in class hours. Training in this sense is necessary and research is also carried out and documented in the "*Journal of STEM Teachers Education*".

Students who study technology and engineering through an integrative STEM education approach learn about the technological world that inventors, engineers, and other innovators have created. Among other things, they study how energy is generated from coal, natural gas,

[1] Standards for Technological Literacy: Content for the Study of Technology – 3rd Edition: ITEEA
[2] K. De la Paz: "Technology and Engineering Bring STEM to Life!", Technology and Engineering Teacher **73**(1), 2013

nuclear power, solar power, as well as when and how it is transmitted and distributed. They examine communication systems: telephone, radio and television, smart devices, satellite communications, fiber optics, and the Internet. They delve into manufacturing and materials—processing industries, from steel and petrochemicals to computer chips and household appliances. They investigate transportation, information processing, and medical technology. They investigate new technologies, such as genetic engineering and emerging technologies, such as fusion power and soft robotics. The goal is to produce students with a more conceptual understanding of technology and engineering and its place in society. These students can conceptualize and evaluate new technologies that they may have never before seen. By "doing and making," children are able to become "makers" for the future.

NAE stated that PreK-12 engineering education must promote engineering "habits of mind" (NAE, 2014). Engineering habits of mind are aligned with what many believe are essential skills for citizens in the 21st century (Partnership for 21st Century Skills, 2011). In addition to understanding how particular technologies are developed and used, students should be able to evaluate the technologies' impacts on the environment, on other technologies, and on society itself. Technologies inevitably involve trade-offs between benefits and costs and intelligent decisions made about technology need to be considered. Students come to see each technology as neither good nor bad in itself, but one whose costs and benefits should be carefully weighed before deciding if it is worth developing.

Engineers, architects, computer scientists, technicians, and others involved in technology use a variety of approaches to problem solving, including troubleshooting, research and development, invention, innovation, and experimentation. The engineering design process typically begins with defining the human need, want, challenge, or opportunity. After investigating and researching the human need, want, challenge, or opportunity, the designer generates several ideas for solutions. Then, considering the original criteria, along with various constraints, one design, or, in some cases more than one, is chosen as the most promising. The selected design is modeled and tested, and then reevaluated. If necessary, the original design is dropped, and another tried. Eventually through a series of iterations that repeat the variable steps of the process as necessary, a final design is chosen.

Technological studies are ideal as an interdisciplinary integrator of all subject content. When taught effectively, technology is not simply one more field of study seeking admission to an already crowded curriculum, pushing others out of the way. Instead, it reinforces and complements the material that students learn in other classes—Technology and Engineering Bring STEM to Life!

Technological and engineering literacy is the ability to use, manage, assess, and understand technology. A technologically and engineering literate person understands, in increasingly sophisticated ways that evolve over time, what technology is, how it is created, and how it shapes society, and in turn is shaped by society. A technologically literate person will be comfortable with learning about technology and engineering, without being afraid or intimidated by it.

Learning to understand and thrive within the framework of technology and engineering, technological and engineering literacy benefits students in several ways. For future engineers, aspiring architects, or students who will have jobs in one area of technology or another, it means they will leave high school with a head start on their careers. They will already understand the basics of such things as the design process and possess a big picture of the field they are entering. This will allow them to put the specialized knowledge they learn later into a broader context.

The understanding and support of the general public about the role of technology and engineering can have a critical impact on funding and support and can compel parents to guide their children toward more technology and engineering courses, motivate the students themselves to see the value of being better prepared for whatever their future has in store.

STEM is an important force in our economy; anyone and everyone benefits by being familiar with it. On the individual level, technological and engineering literacy allows consumers to better assess products and make more intelligent buying decisions, policy decisions, and those that affect our quality of life. Focusing on the integration of science, technology, engineering, and mathematics while using technology and engineering as a catalyst allows teachers to engage students in meaningful real-life contexts. These technological and engineering contexts bring attention to the increasingly important role that STEM plays in our society and emphasize how STEM affects our everyday existence. Technology and Engineering Education through Integrative STEM education effectively delivers technological literacy and engineering and paves the way for making a positive difference in the lives of humankind!

In digital society users pay especially big attention to their user experience (UI/UX). Positive experience using different apps for health care, medicine or other purposes is very important, therefore multimedia engineering is important and students should have opportunity to become familiar with various tools for creating and editing audio, video, 3D graphics, creating games and other interactive graphic applications, to create an attractive experience for users.

Bioinformatics students analyze and interpret the vast amounts of gene and protein information stored in computer databases worldwide. It is a new, rapidly evolving field of science resulting from the interaction of computer science, molecular biology, and biochemistry. Industrial biotechnology students[3] are learned to incorporate biological and engineering applications of scientific knowledge into industry (chemistry, bio-pharmacy, biofuels, biopolymers, bioplastics). Students studying biotechnology are aimed to solve problems in biotechnology; select installation and project technologies; integrate knowledge of management and applied technology in the bio-industry.

Food Science and Technology students[4] can acquire the interdisciplinary competencies and skills required for future food technologist in the areas of food chemistry, microbiology, nutrition technology and engineering while integrating this knowledge with fundamentals of entrepreneurship and economics.

The changing climate promotes a qualitatively new concept of social responsibility and environmental protection. The rapidly evolving field of environmental engineering and technology aims to provide a safe and quality living the environment on Earth. After graduation, you can become an expert in climate change management, environmental engineering and technology, environmental public opinion, work in eco-innovation clusters, and create and manage digital content.

Students who are studying artificial intelligence[5] are capable not only apply but also fundamentally understand artificial intelligence algorithms, evaluate algorithm performance,

[3] https://stojantiesiems.ktu.edu/programme/b-pramonine-biotechnologija/
[4] https://stojantiesiems.ktu.edu/programme/b-maisto-mokslas-ir-technologija/
[5] https://stojantiesiems.ktu.edu/programme/b-dirbtinis-intelektas/

develop models for image and language processing and implement machine learning algorithms. They are able to select appropriate system architecture parameters and implement intelligent solutions. These solutions can help health care, healthy lifestyle, automation processes, etc.

Data Science and Engineering students are focused on the application of data science methods in information systems. They tend to be qualified interdisciplinary professionals with knowledge of mathematics and computer science related to data science and data engineering, with mathematical and algorithmic thinking skills, able to recognize data management and analysis problems in organizations information systems, develop, program, and apply data science models systems research and decision-making, and integrate them with enterprise information systems using advanced database management and quality assurance technologies. They able to creatively apply knowledge gained in various information system development situations, critically evaluate data and analytics results; able to work in an interdisciplinary team and constantly develop your professionalism.

Robotics and cybernetics students are capable of designing, deploying, and servicing robots and their systems used in various industries, the public sector, aerospace and military, domestic, etc., combining classic mechatronics solutions, control algorithms, artificial intelligence and various computer senses. Students acquire basic engineering knowledge, industrial robot systems design skills, industrial control programming. Learning how to analyze and control electromechanical processes, analyze production processes, select hardware and software, develop control strategies and algorithms using artificial intelligence, computer vision, the Internet of Things, based on the challenges of Industry 4.0.

Studying renewable energy students should develop understanding about the technology, state-of-the-art equipment and innovative projects; acquire knowledge in the design and application of hybrid systems for renewable energy sources, active and smart power grids, energy devices. Students learn to design systems for renewable energy management and to acquire skills in applying information technology to renewable energy.

Students in different STEM study programs have possibilities to choose different projects and solve different problems related to health care, medicine, sustainability and so on. They by themselves identify different problems which they want to solve. They investigate and research the need for a particular problem-solving perspective, generate different ideas on how to solve a particular task. After this step students construct a framework for the problem solving, make necessary models. Then they should prepare some prototype, test it, identify the problems and to eliminate them. After this stage to test the prototype one more time.

Need Analysis in Germany

In German society, economy, and school policy the topic STEM is of great importance and is discussed and dealt with on many levels. In German-speaking countries, STEM is known as MINT and is the abbreviation for the departments of mathematics, computer science, natural science, and technology. The MINT Autumn Report of the German Economic Institute (IWD), which is published annually, is a central document in the assessment of the state of affairs and the demands made on the MINT subjects[6].

The report in its version of autumn 2019 stated that in Germany at the end of 2018 there were approximately 500,00 vacancies in the labour market in the area of MINT subjects and unemployment in this area is at its lowest level since 2011. At the same time, it was noted that digitisation in Germany does not meet the requirements of this development and needs to be improved. The demographic development expected at the same time aggravates this situation, as many MINT professionals will retire in the coming years and their vacancies cannot be filled. The study sees this development as a threat to the innovative strength of German society and calls for significant efforts in education and research as a reaction.

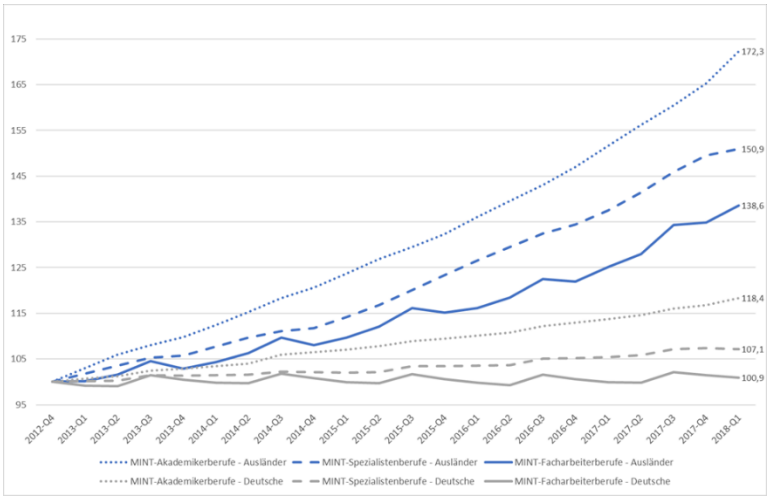


Figure 1: Employment development by MINT occupational aggregates: Akademikerberufe (Academics), Spezialistenberufe (Technicians), Facharbeiter (Training professions); Ausländer (Foreigner), Deutsche (Germans).

Source: Bundesagentur für Arbeit[7]; IWD[8]

[6] https://www.iwkoeln.de/
[7] https://www.arbeitsagentur.de
[8] https://www.iwkoeln.de/

The mentioned discrepancy between the requirements and the status quo is summarized by the introduction of the term "MINT-Gap". According to the authors, the MINT gap has not only increased in size but also changed in its structure in recent years. It can be seen...

"*...that the share of non-academic occupational categories (skilled workers, master craftsmen, technicians) in the total gap has risen continuously and now stands at 68.6 percent. The share of academic MINT occupations is correspondingly 31.4 percent. IT experts in particular are increasinglyneeded due to digitisation. Here, the gap has more than doubled in the past three years from 19,500 in October 2015 to 40,500.*"[9]

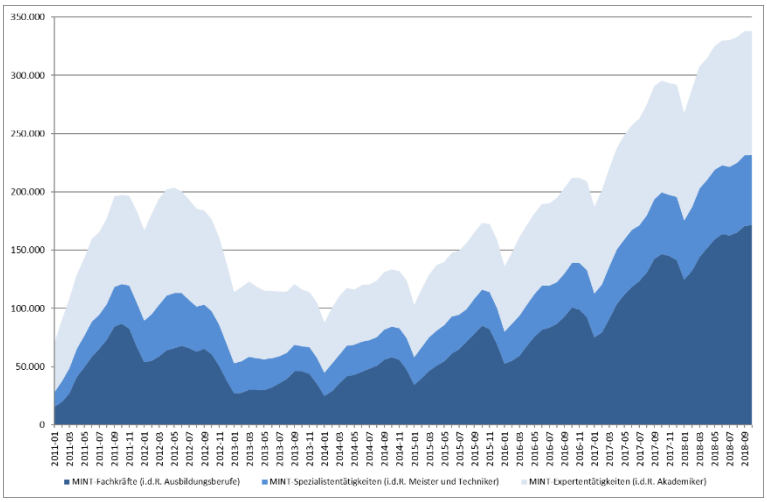


Figure 2: MINT-Gap: Fachkräfte (Training professions), Spezailistentätigkeiten (Technicians), Expertentätigkeiten (Academics)

Source: Bundesagentur für Arbeit[10]; IW-Zukunftspanel[11]; IWD[12]

[9] Axel Plünnecke: MINT Autumn Report Statement, Institut der deutschen Wirtschaft, 11-2018

[10] https://www.arbeitsagentur.de

[11] https://www.iwkoeln.de/studien/iw-studien/beitrag/das-iw-zukunftspanel-62761.html

[12] https://www.iwkoeln.de/

As central challenges in response to this development, the authors of the study highlight the following points[13]:

1. Strengthening vocational and study orientation and MINT education

„*In the education sector, MINT education should be strengthened on a broad scale. To this end, it is important to strengthen the training maturity of young people, especially in the STEM competencies. The latest IQB study[14] shows that the scientific skills of ninth-graders have largely stagnated in recent years, and in the subject of chemistry the level of specialist knowledge has even declined somewhat*."

2. Strengthen IT skills of students

„*Companies are increasingly permeated with information and communication technologies, especially computers and the Internet. As a result, information and communications technologies are increasingly being used as working tools at many workplaces, and information processing is thus gaining in importance. For this reason, it is becoming more and more important that comprehensive IT skills are already taught in the education system. In order to be prepared for the social and economic changes that digitisation will bring, the teaching of digital skills must be firmly established from school to adult education*. "[15]

3. Exploiting the potential of immigration from third countries

„*With regard to immigration from third countries, the Federal Government has provided important impulses in the form of the Blue Card and further improvements in immigration channels. To this end, the government is specifically recruiting academic experts in the MINT professions in third countries. With success: The employment of foreigners from third countries (excluding the 4 main countries of origin of the refugees) in academic MINT occupations has increased by 42,000 or 139 per cent between 31 December 2012 and 31 March 2019 from 30,300 to around 72,300. The additional 42,000 employees from third countries alone contribute to the annual value added of almost 4.8 billion euros."*

4. Promote research

„*In order to strengthen Germany's innovative strength and to achieve the 3.5 percent target of R&D spending as a percentage of GDP, a research allowance law has been passed (by the Federal Government) which will come into force on 01.01.2020. The tax research allowance is intended to ensure that small and medium-sized enterprises in particular invest more in research and development activities. The annual costs to the state for the research allowance are estimated to increase from 1.15 billion euros in 2021 to around 1.3 billion euros in 2024. Researching companies will be legally entitled to funding of 25 percent of the eligible expenses up to a limit of 500,000 euros per year, so*

[13] Institut der deutschen Wirtschaft, MINT Autumn Report 2019

[14] Petra Stanat (Edt.) 2019, IQB-Bildungstrend 2018

[15] Oliver Falck, Simone Schüller, 2016, Querschnittstechnologie Internet – Universallösung für den Arbeitsmarkt der Zukunft?, in: Wirtschaftsdienst, 96. Jg., Nr. 8

that the allowance in particular can provide incentives for small and medium-sized companies. Contract research on behalf of the client is also supported, so that SMEs without their own research staff also have incentives to develop new products and processes in cooperation with universities or non-university research institutions. The research allowance also provides support for companies such as start-ups which are not yet making a profit."

A number of publicly and privately organised initiatives have emerged in Germany to respond appropriately to these developments. They are dedicated to various aspects of MINT subjects such as primary schools, the promotion of women and the integration of migrants. The following is a list of examples of the most important initiatives and their self-presentation:

- *Nationales MINT Forum*[16]

The Forum sees it as successful that promote MINT education along the entire education chain and to raise awareness of the importance of these competences in all areas of society. In order to achieve this goal, all actors involved in education at different levels must work together and in a coordinated manner. On the basis of these convictions, more than 30 institutions involved in MINT education have joined forces in the National MINT Forum since 2012 on the initiative of acatech - German Academy of Science and Engineering and the BDA/BDI initiative "MINT Zukunft schaffen" (Creating MINT the Future)"

- *Foundation Haus der kleinen Forscher (House of Little Explorers)*[17]

The non-profit "Haus der kleinen Forscher" Foundation is committed to good early education in the domains of science, technology, computer science, and mathematics with the aim of strengthening children for the future and enabling them to act in a sustainable way.

- *MNU - Association for the promotion of MINT teaching*[18]

Since 1891, the MNU has been committed to quality and progress in mathematical and scientific school subjects. We support teachers in their challenging work and the further development of professional skills through practice-proven advanced training and professional dialogue.

- *Komm, mach MINT* [19]

The National Pact for Women in MINT Professions "Komm, mach MINT" is the only nationwide network initiative that inspires girls and women to take up MINT studies and professions. It already networks more than 300 partners from politics, business, science, social partners, the media and associations, and translates the dialogue on women and MINT into innovative measures.

[16] https://www.nationalesmintforum.de/
[17] https://www.haus-der-kleinen-forscher.de/en
[18] https://mnu.de/index.php
[19] https://www.komm-mach-mint.de/

- *MINT Zukunft schaffen*[20]

The initiative aims to contribute to a positive attitude towards MINT on the part of young people, parents and teachers. The "MINT-friendly schools" initiative also addresses primary schools as a target group in order to avoid a break in school transitions. The "Digital School" programme, which will be launched in 2017, will give all schools the opportunity to take a position on "digitisation".

- *MINT-EC*[21]

MINT-EC is the national excellence network of schools with upper secondary education and an outstanding mathematical, scientific and technical school profile. Its aim is to support the lighthouse schools in their development into MINT talent forges with high-calibre offers for pupils, teachers and school administrators."

- *+MINT Talentförderung*[22]

The nationwide association for the promotion of MINT talent was founded with the aim of consistently and purposefully promoting the best MINT talents in the school sector. The association sets up MINT excellence trains for boarding schools in all German states and organizes the nationwide scouting of gifted students. According to its statutes, the purpose of the non-profit association is to promote education and upbringing. The association will promote particularly talented students in the field of education MINT, regardless of their social background and nationality.

The fundamental objectives of the initiatives are also comprehensively supported and actively backed by the German government. The Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung - BMBF) acts as a financial and/or ideational supporter and summarises its initiatives in its MINT Action Plan. The ministry itself summarises this plan in four subsequent fields of action:

1. field of action: MINT-education for children and young people
2. field of action: MINT-Professional
3. field of action: opportunities for girls and women in MINT
4. field of action: MINT in society

Need Analysis in Italy

The latest edition of the "Education at glance" report[23] of the International Organization for Economic Cooperation and Development stated that Italy spends less than other countries to train the workers of the future and continues to spend less and less; on the contrary our competitors continue to raise the investment bar.

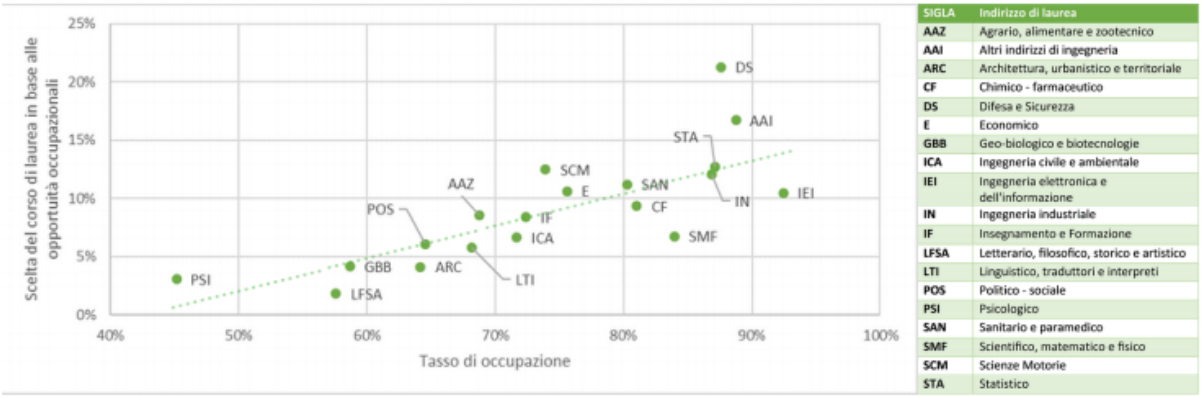
Of course, young people entering the labour market are paying for this delay, moreover in a weak economic context, and consequently companies, which cannot find profiles in line

[20] https://mintzukunftschaffen.de/

[21] https://www.plus-mint.de/

[23] OECD, "Education at a Glance 2019": OECD Indicators, OECD Publishing, Paris, 2019.

with the challenges posed by an increasingly global economy and digital. However, the misalignment is also linked to the paths that boys and girls tend to prefer for their academic career. There are some paths which, despite the far from favourable scenario, guarantee better opportunities in terms of job placement. A great example could be the disciplines collected by the acronym "STEM": Science, Technology, Engineering and Mathematics. Today, graduates in these subjects represent real treasures for companies thanks to skills acquired in all sectors to compete in the digital age. According to the same report, in Italy students who are attending STEM subjects have the prospect of a much easier entry into the job world, with an employability rate of over 85%. Independent research has confirmed that the probability of undertaking STEM-oriented study courses is higher among those who had the opportunity to approach scientific and technical subjects already during childhood and the first years of school but it is enough to consult the most documented statistics on the subject to realize that the disparity between the demand and supply of STEM skills continues to widen.



SIGLA	Indirizzo di laurea
AAZ	Agrario, alimentare e zootecnico
AAI	Altri indirizzi di ingegneria
ARC	Architettura, urbanistico e territoriale
CF	Chimico - farmaceutico
DS	Difesa e Sicurezza
E	Economico
GBB	Geo-biologico e biotecnologie
ICA	Ingegneria civile e ambientale
IEI	Ingegneria elettronica e dell'informazione
IN	Ingegneria industriale
IF	Insegnamento e Formazione
LFSA	Letterario, filosofico, storico e artistico
LTI	Linguistico, traduttori e interpreti
POS	Politico - sociale
PSI	Psicologico
SAN	Sanitario e paramedico
SMF	Scientifico, matematico e fisico
SCM	Scienze Motorie
STA	Statistico

Figure 3: Employment rate and choice of degree course based on employment opportunities for different degree groups.

Source: https://laureatiliberamente.it/blog/sbocchi-lavorativi_C5/quale-corso-di-laurea-scegliere-ingegneria-si-conferma-la-facolt-pi-professionalizzante-per-il-futuro-33

According to the data of the ministry of the education, the students who choose to continue their higher education by focusing on the STEM disciplines are just one third of the total, with a particularly low peak of 15% if it is computer science but in less than ten years the demand for STEM jobs will triple compared to traditional jobs. According this scenario, it is also very probable that in the same period, robots and automated systems of various kinds will have replaced several million workers

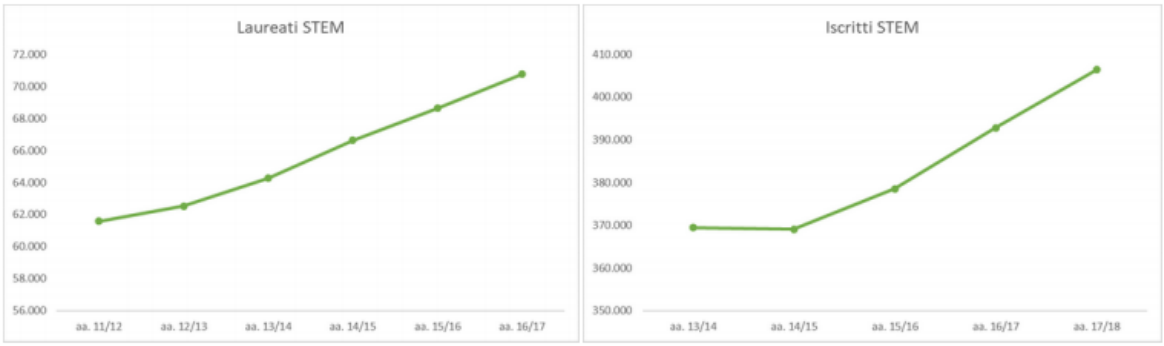


Figura 1 - Aumento dei laureati STEM dall'Anno Accademico 11/12 al 16/17

Figura 2 - Aumento degli iscritti STEM dall'Anno Accademico 13/14 al 17/18

Figure 4: (right panel) Increase of STEM graduates from the Academic Year 11/12 / to 16/17

(left panel) Increase of STEM undergraduates from the Academic Year 13/14 / to 17/18

Source: https://laureatiliberamente.it/blog/sbocchi-lavorativi_C5/quale-corso-di-laurea-scegliere-ingegneria-si-conferma-la-facolt-pi-professionalizzante-per-il-futuro_33

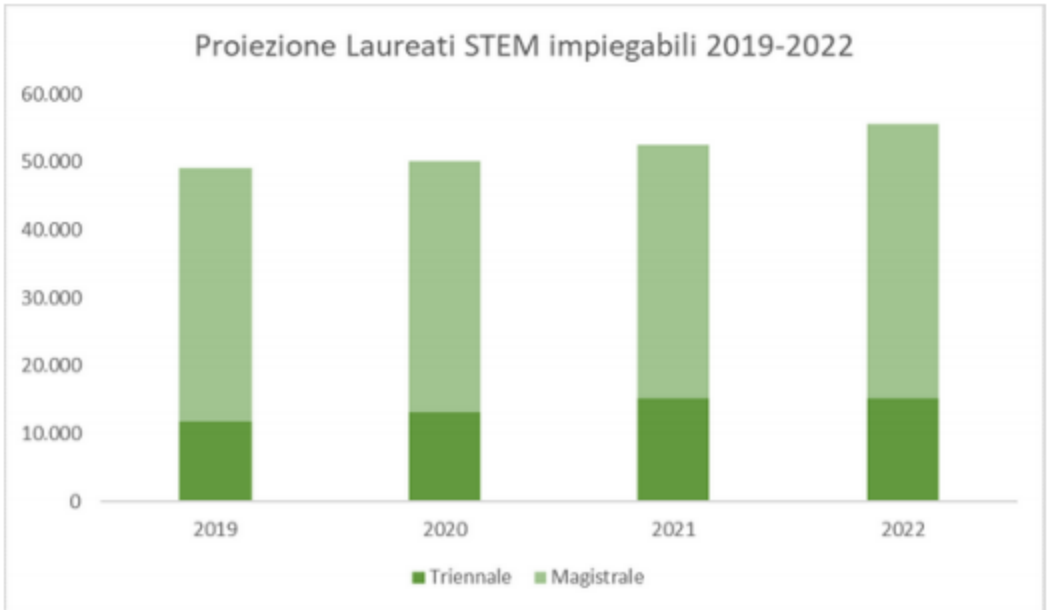


Figure 5: screening of STEM graduates from 2019 to 2022

Source: https://laureatiliberamente.it/blog/sbocchi-lavorativi_C5/quale-corso-di-laurea-scegliere-ingegneria-si-conferma-la-facolt-pi-professionalizzante-per-il-futuro_33

In addition, a problem presented in all European countries, although not too much highlighted, is the misalignment between the demands of the labour market and the offer of tertiary education in the STEM field. STEM degrees, excluding specific sectors, in ICT and in some branches of engineering, do not actually offer career benefits compared to other degrees often offered on various occasions. Indeed, the areas of social and economic sciences where the cost / benefit ratios are better than the STEM sciences emerge as more aligned with career opportunities. This is confirmed in many European countries including France and Italy where the value of the cost benefit ratio of STEM degree calculated five years after

graduation is negative for women and positive for men. Much more negative values for men than women are recorded in the areas of humanities, which suggests why women tend to choose non-STEM disciplines.

The issue of the gender gap in STEM disciplines is naturally complex and cannot be resolved with explanations based only on a more or less conscious choice based on convenience long-term[24]. For example, in mathematical cognitive skills, only in standardized tests and not in school assessments, males outnumber females with significant percentages and only in the extreme parts of the queues, but this does not enough to explain the much wider disproportion between males and females in the STEM professions. Another piece of evidence that can help explain the gender gap concerns relative cognitive strength: mathematics vs. verbal. When individuals have equally strong mathematical and verbal skills (women tend to have more balanced mathematical and verbal skills than men), their skills are likely to affect their interests and values, which may explain why women with high Mathematical and verbal skills are more likely to choose more practical or applied non-STEM challenging fields, unlike mathematical intensive STEM fields which are more theoretical or mechanical. Relative cognitive strengths seem to guide career choices in STEMs rather than absolute cognitive skills and be a primary factor explaining the shortage of women in STEM-intensive mathematical careers.

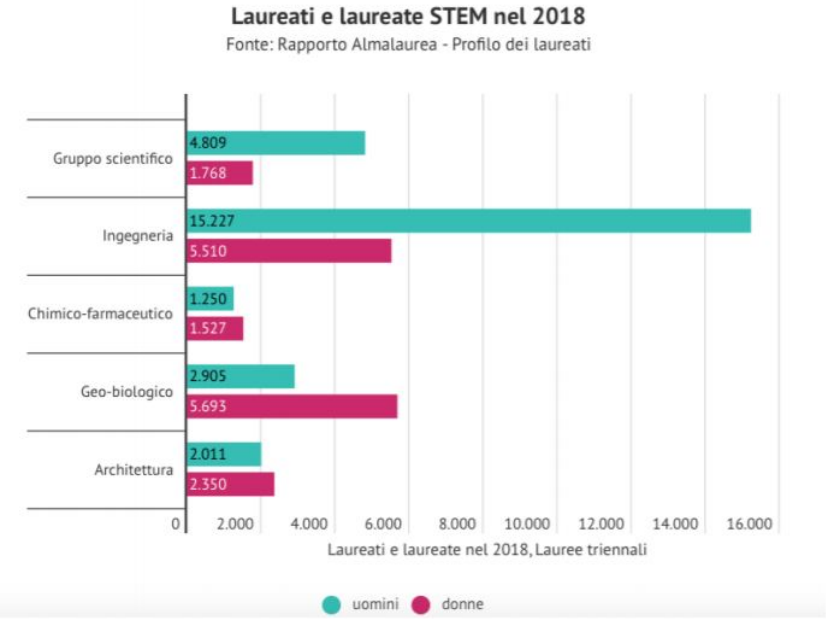


Figure 5: Percentage of female and male graduates in the STEM area.

Source: https://www.ipresslive.it/comunicates/26608/in-italia-solo-12-donne-su-1000-si-laureano-in-discipline-stem-e-il-loro-stipendio-e-inferiore-a-quello-dei-ragazzi-fin-dal-primo-anno

[24] Consorzio Interuniversitario Almalaurea, "Lauree STEM: performance universitarie, esiti occupazionali e gender gap", 2019.

The family environment also plays an important role. For example, research has found that parents with stronger stereotyped gender beliefs about mathematics have higher perceptions of math skills than their daughters. The family environment plays a role not only with respect to gender differences in mathematics performance in favor of boys, but also in gender differences in verbal performance in favor of girls. In addition, gender differences in career interests also contribute to the under-representation of women in areas of high mathematical intensity. A meta-analysis showed that males prefer to work with objects, while females prefer to work with other people.

Another factor, which can also be explained from the point of view of socio-cultural stereotypes, concerns the gender differences in lifestyle preferences or the priorities that women and men attribute to the family over career. Not only are women more willing than men to make professional sacrifices for the sake of their families, they also prefer less work-centered lifestyles than their male colleagues.

To conclude some ideas to better orientate the students, in particular those with both high mathematical and verbal skills, towards STEM professions are:

1. From primary and secondary schools to understand how the use of ICT and mathematics is important for improving the quality of daily life and how it is therefore related to the medicine professions, but also to professions related to the field of art and humanities. This can also produce an increase in interest in the STEM professions which otherwise, as already seen, with the same capacity, would be more easily discarded by the students.

2. Improve teaching in science and mathematics with a greater attention to collaboration between students and teaching problems.

3. Combat gender stereotypes that still persist in favor of males and at the expense of females in the context of STEM.

4. Conceive the use of STEMs differently between vocational education and general education, particularly if it is basic education.

5. To underline, especially at school, the importance of commitment and seriousness and care in dealing with studies, factors that are powerful tools for intellectual growth also in the mathematical and scientific fields.

Given the better verbal skills of females compared to males, connecting scientific disciplines to aspects of their historical development and also to the biographies of important scientists would improve the interest and results of them. These are just some ideas concerning the field of school education, certainly the orientation in the choice of tertiary education pathways and work policies in favor of women cannot remain unrelated to the problem, if you want to face it with the appropriate willingness to improve the situation.

In Italy, many initiatives are emerging that are resident in the STEM world. Some of these are:

- *Deploy Your Talents*[25]

CA Technologies believes in partnerships between businesses, schools and non-profit organizations as a winning formula in guiding young people towards training courses that offer concrete employment opportunities. A successful example is the collaboration with the Sodalitas Foundation as part of the Deploy Your Talents initiative, which for three years has involved hundreds of students to promote the value of training in STEM subjects, helping to reduce the lack of resources in the technical-scientific field. and overcome gender stereotypes.

CA Technologies will make its experiences and skills available to about 140 students, guiding them on a path aimed at gaining greater awareness of their skills, emphasizing possible future professional opportunities in the technical and scientific field.

- *STEM in the City*[26]

Three years ago the Municipality of Milan launched STEMintheCity, an initiative born in collaboration with important realities in the public and private sector, and with the support of the United Nations, which set itself the ambitious goal of removing the cultural stereotypes that drive girls away from study paths and technical-scientific careers, reduce the gender gap in this sector and spread the culture of STEM[27].

This year, from April to May 8 with the STEM marathon, the city came alive with meetings, events, courses training, shows that have seen the active participation of citizens and the involvement of all schools, from those of childhood to universities.

- *Stem by women*[28]

Stem by Women is an initiative of an association of the same name which is supported by the Polytechnic University of Turin and the University of Turin, as well as by several international companies including Amazon, Avio Aero and Comau. This partnership will organize a series of meetings that will allow the participating girls (university students in STEM degree courses, but also high school girls who are getting oriented) to 'get inspired' and learn more about the career that can be done in these areas, listening the testimonies of several HR Directors and Executives of the associated companies and of meeting twenty dedicated "role models", professionals and company managers who work with passion and success in the Stem area at dedicated tables. The first meeting took place on May 16.

[25] https://www.sodalitas.it/fare/giovani-e-futuro/deploy-your-talents

[26] https://www.steminthecity.eu/

[27] Comune di Milano, “STEMinthe City editoriale”, edizione 2019

[28]https://www.university2business.it/2019/05/24/stem-by-women-ecco-liniziativa-che-spiega-alle-ragazze-come-e-perche-fare-carriera-in-ambito-tech/

- *PALERMOSCIENZA*[29]

Experience inSign is a scientific event organized by the PALERMOSCIENZA Association which, every year comes to life at the University of Palermo (Building 19 - Viale delle Scienze) and allows all visitors to enter the world of science through activities that leave the " sign". The event, now in its thirteenth edition, is in fact structured to make the learning process immersive and fun thanks to a wide variety of initiatives aimed at schools, institutions and the city.

Need Analysis in Lithuania

The topic STEM is of great importance in Lithuanian. Different organizations, institutions and politicians agree that the common efforts in STEM field nowadays will have an impact on the future of the country. All the parties agree that education in STEM field is directly related to the market growth and solving different social problems.

Proprietary companies predict that modern technology implementation will rise the need for more sophisticated, creative and interdisciplinary thinking professionals. The Fourth Industrial Revolution is a new stage[30] in economic development that requires understanding in big data, artificial intelligence, Internet of Things, robotics, 3D printing etc. and should be in combination with physical, digital and biological interactions. According to some prognosis[31] in a five-year perspective the greatest need for professionals will be in robotics engineering, data analytics and information technology areas, while the need for a low-skilled will decrease. Students studying in different disciplines such as industrial biotechnology, food science and biotechnology, artificial intelligence, data science and engineering, robotics and etc. have to have the ability to understand different technological and physical processes, must be capable of critical thinking, adaptation of the problem solving approach; to have a capability to analyse data and processing flows, to have a capability to integrate different interdisciplinary approaches.

There are efforts on different national levels to address the challenges of the lack of STEM professionals. In summer of 2019, the Lithuanian government representatives announced[32] that the state will fund studies for anyone who has chosen to study in STEM fields this year. In total, 5555 state-funded places are awarded in universities and colleges for mathematics, computer science, physical, engineering and technology studies. 1,655 places are devoted to business and public management, and 1,358 seats to health sciences, 1285 places were funded in the social sciences and 1080 places in the humanities. This decision was based on different analysis and studies and current demand. There is a big attention to the ICT (information and communication technologies) field as well as to the industrial engineering's areas.

[29] https://www.palermoscienza.it/esperienza-insegna/

[30] https://eimin.lrv.lt/lt/veiklos-sritys/verslo-aplinka/pramone/pramone-4-0

[31] Inžinerinės pramonės specialistai Lietuvoje: kaip tinkamai pa(si)ruošti greičiau nei bet kada. 2019, January. "Investuok Lietuvoje"

[32] https://www.lrt.lt/naujienos/lietuvoje/2/1059999/studiju-finansavima-tiksliukams-ekspertai-vertina-skeptiskai-pelningus-darbus-tures-ne-visi

Research made by ICT companies association "Infobalt", investment development agency "Investuok Lietuvoje" and Science and Studies Monitoring and Analysis Center "Mosta" stated that in 2020 there will be additional demand of 13,300 ICT specialists in Lithuania[33] (see Figure 3). Another study[34] had the purpose to evaluate how Lithuanian labour market and the formal education system succeeds in addressing industrial engineering shortage of specialists and getting ready for new technologies driven change. Three organizations joined forces: Lithuanian engineering industry LINPRA Association of Science and Study monitoring and analysis Center (MOSTA) and investment development agency "Investuok Lietuvoje".

KIEK IR KOKIŲ IRT SPECIALISTŲ
REIKIA LIETUVOS ĮMONĖMS?

Profesija	Poreikis iki 2020 m.
1. Programuotojas	1983
2. Jaunesnysis programuotojas	1301
3. IRT konsultantas	1260
4. Vyresnysis programuotojas	847
5. Projektų vadovas	599
6. Testuotojas	527
7. Vartotojo sąsajų kūrėjas	434
8. Sistemų architektas	351
9. Informacijos saugumo administratorius	330
10. Informacinių sistemų grafikos dizaineris	330
11. Vadovaujantis programuotojas	320
12. Sistemų administratorius	310
13. Informacinių sistemų analitikas	299
14. Jaunesnysis testuotojas	299
15. Pagalbos centro konsultantas	289
16. Vyresnysis sistemų administratorius	268
17. Vyresnysis IRT aptarnavimo inžinierius	248
18. Jaunesnysis sistemų administratorius	237
19. IRT aptarnavimo inžinierius	227
20. Tinklų inžinierius	227
Kitos profesijos	2643
Iš viso:	13331

Figure 6. The need of professionals in ICT sector and their positions

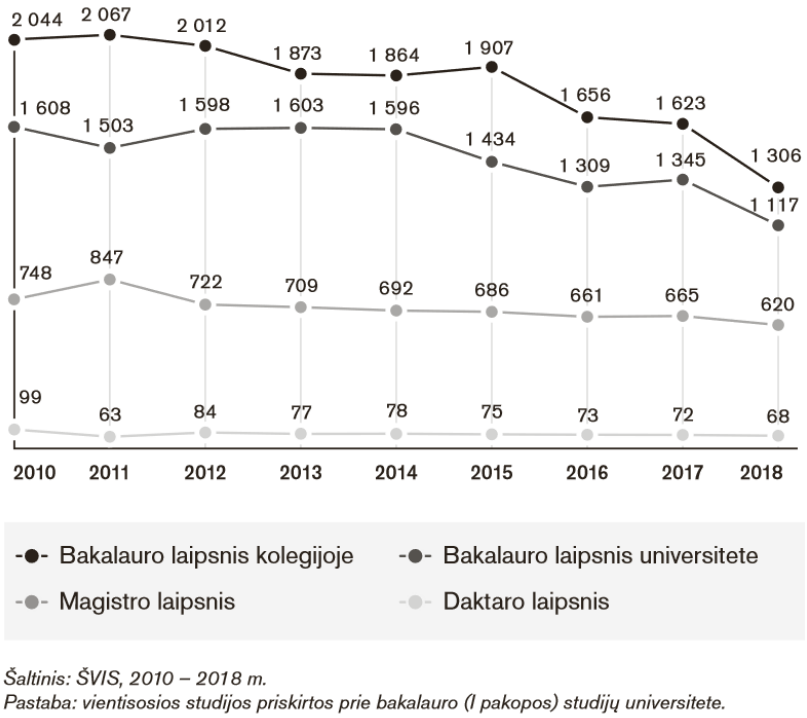
In the context of the Lithuanian labor market the group of industrial engineering specialists appeared to be relatively small and distributed over various sectors of the economy. In 2017 the number of employees in industrial engineering was 21,260 and accounted as 1.62 percent of all jobs in the country. For comparison, in the same period the country had about 52,100 positions in sales, marketing and public relations professionals, 22,600 information and communication technologies specialists, about 8 860 persons were employed in ICT related jobs.

[33] IRT specialistai Lietuvoje: situacija darbo rinkoje ir darbdavių poreikiai. "Investuok Lietuvoje", "Inforbalt". https://investlithuania.com/wp-content/uploads/2018/03/IRT-specialistai-Lietuvoje.pdf
[34] Inžinerinės pramonės specialistai Lietuvoje: kaip tinkamai pa(si)ruošti greičiau nei bet kada. 2019, January. "Investuok Lietuvoje"

Investigation on how much ICT professionals are currently being trained in higher education and vocational schools have shown that the capacity of the formal education system to meet the human resource needs for ICT companies is currently very limited. Despite the steadily increasing popularity and enrollment in ICT studies, only slightly more than a half of the students complete their study programmes. Equally important in this context is the quality of studies and the preparation of graduates for work.

Lithuanian engineering industry disproportionate between men and women distribution. The investigation revealed[35] that as much as 80 percent currently working engineering professionals are men. Women made up the majority only in comparatively scarce chemistry engineering and engineering technicians in occupational groups. The smallest group (up to 12 percent) worked in electrical and electronics, mechanical engineering fields. Negative demographics[36] trends in the country and consequently consistent declining number of entrants to higher education institutions do not satisfy the engineering industry needs and gaps in relevant study areas.

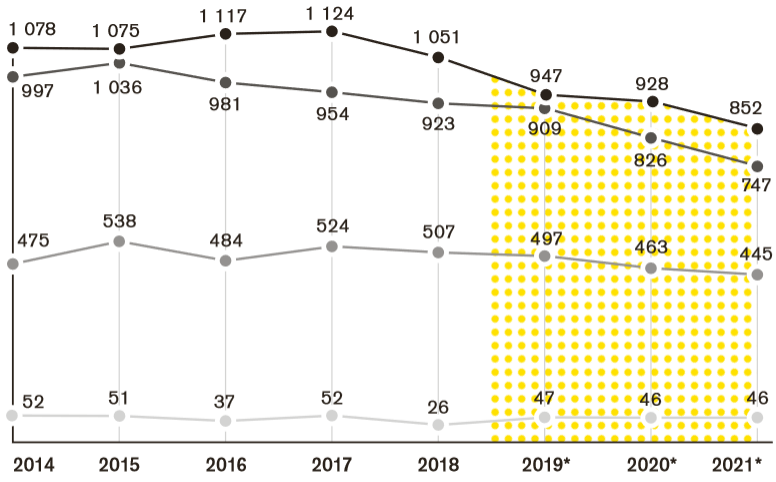
The decreasing number of entrants of engineering studies in 2014-2018 are seen in all study levels (see Figures 7 and 8).



Šaltinis: ŠVIS, 2010 – 2018 m.
Pastaba: vientisosios studijos priskirtos prie bakalauro (I pakopos) studijų universitete.

Figure 7. The decrees of industrial engineering entrants (2010-2018)

[35] Inžinerinės pramonės specialistai Lietuvoje: kaip tinkamai pa(si)ruošti greičiau nei bet kada. 2019, January. "Investuok Lietuvoje"
[36]https://strata.gov.lt/lt/naujienos/8-naujienos/555-letejancios-ekonomikos-fone-augantis-issilavinusi-darbuotoj-poreikis-ir-gilejanti-atskirtis



Šaltinis: ŠVIS, 2010 – 2018 m.

Figure 8. The changes of industrial engineering graduates in 2014-2018 and forecasts 2019-2021

The analysis[37] shows the decrease of entrance number into life science bachelor and master studies as well. In 2011/12 the number of entrances was 617 and in 2019/20 reached just 457 applicants (the decrease of 26 percent) (see Figure 9).

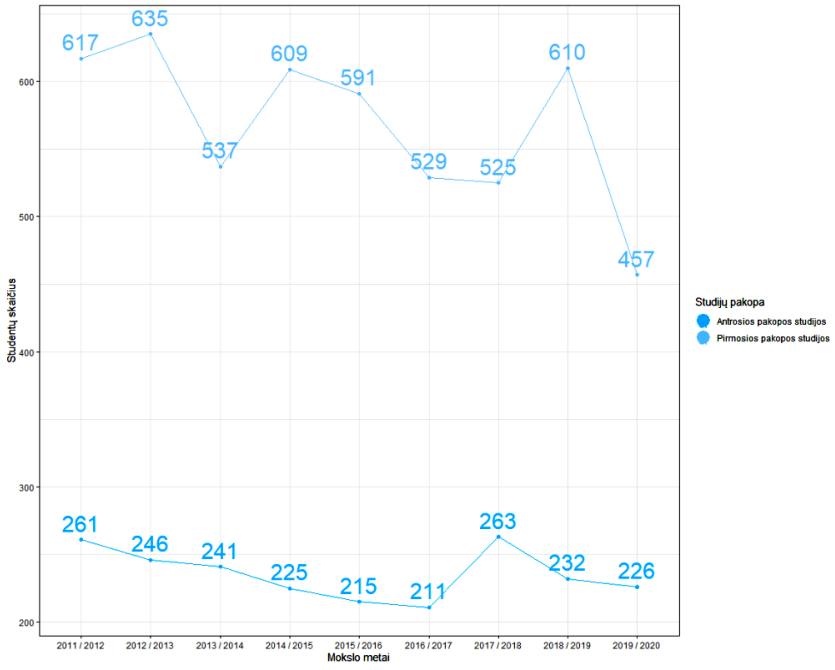


Figure 9. The number of life science studies entrants from 2011/12 to 2019/20.

[37]Gyvybės mokslų krypčių grupės trumpa apžvalga. https://strata.gov.lt/images/tyrimai/2020-metai/svietimo-politika/krypciu-apzvalgos/Gyvybes_mokslai.pdf

There are 33 study programmes related to life science in Lithuania in 2019/20. Vilnius University pursue 14 programmes and have 57 percent students of life science program.

The authors of the studies [38] [39] highlight the points related to challenges and make some proposals. Some of them: to harmonize the IT specialists demand and labour market needs through increasing state-funded STEM studies; to create and execute specialised educational programs, designed for exceptionally talented students; to develop and implement a plan for teachers' information technology competencies upgrade as well as prepare recommendations for teachers "how-to" information technology can be integrated into a subject of an education program content; to ensure 10 open access centres of natural science, technology, engineering, mathematical research and experimental activities (STEM) establishment in regions; to increase IT and technical creativity in the field of non-formal education of children in a number of programs, technical creative direction of informal children educational programs; to increase the number of teachers who are able to implement STEM direction in non-formal education of children programmes for beginners and for students. This would consider the labor market needs for competence development in vocational training institutions and higher education institutions.

Need Analysis in Turkey

An important report was signed to guide the country's policies in the field of education. Turkey's 500 teachers who work in different provinces of data obtained through interviews with content analysis prepared by subjecting STEM Education Report was presented to the attention of the educational community.

In the STEM Education Report, the first STEM education, the importance and the turning point for Turkey in STEM education are explained. On a world scale, the program of the 1900 integration of the occurrence of thought is accepted while the declaration of the Republic of Turkey in 1923 is considered. In the conclusion part of the report that focuses on the road map that should be followed about how STEM teacher trainings should be conducted. Besides, valuable contributions are made to the Turkey's educational targets for 2023, 2053, and 2071.

[38] Inžinerinės pramonės specialistai Lietuvoje: kaip tinkamai pa(si)ruošti greičiau nei bet kada. 2019, January. "Investuok Lietuvoje". https://investlithuania.com/wp-content/uploads/2019/03/In%C5%BEinerin%C4%97s-pramon%C4%97s-specialistai-Lietuvoje_web.pdf

[39] IRT specialistai Lietuvoje: situacija darbo rinkoje ir darbdavių poreikiai. "Investuok Lietuvoje", "Inforbalt"

"We should focus on education approaches that support technology production and technological production."

We see that technology has an important role in the economic strengthening of countries to find a place among the top 10 countries in the Gross National Product. To be a country that does not use technology but produces, we must definitely focus on education approaches that support technology production and technological production. One of these approaches is basically, the STEM education approach, in which science, technology, engineering and mathematics are integrated in an integrated way with daily life. When we look at the examples from around the world, we believe that STEM will be a useful approach for our country if it is applied correctly. It is obvious that this educational approach should be adopted in order to keep up with the changes occurring in fields such as artificial intelligence, big data, internet of things. The STEM education approach included in the education system with the right methods; As a country, it will also contribute significantly to taking effective steps in areas such as coding and cyber security.

"It is aimed to develop 21st century life skills in STEM education."

As clearly stated in the 2023 Education Vision Document announced by the Ministry of National Education, it is seen that a skill-oriented process in education will be adopted in the upcoming period and accordingly, different workshops will be established in educational institutions. Actually, this process is a situation that is already in STEM education. Because, it is aimed to develop 21st century life skills in STEM education. The point to be sensitive here is that the workshops mentioned in the 2023 Education Vision Document are not left to the hands of non-experts and companies. This is a situation that should be considered in order not to repeat the negativities and inefficiencies that we have experienced in Fatih Project (the national network in education project in Turkey) in the recent past. Establishing workshops in transition to STEM education and improving students' skills is a nice and essential step, but it is important that the right people and institutions take part in this process. It is obvious that the process declared in the 2023 Education Vision Document will bring our country to a good position if we can improve students' skills by applying STEM education with competent names and a local perspective.

The most important factor that motivates us for the preparation of the report is our desire to reveal the correct known mistakes about STEM education. Unfortunately, STEM education is emptied in our country today and even those who do not have enough equipment claim that they can provide STEM education. We wanted to introduce unscientific approaches, as STEM can be taught with one-week training, the mentality of this approach is as simple as "bridging pasta".

When the opinions of 500 teachers from different provinces we use in our report are examined in order to clearly reveal the distorted perspective of the kind we mentioned, it is clearly seen that the danger bells are ringing in our country regarding STEM education. In our report, it was explained in detail that the trainings given to teachers about STEM are far from the required quality, depending on the opinions of the teachers.

"We see that our biggest issue is that teachers are not being properly trained."

The main issue of our education system is to increase the education level of teachers. We see that our biggest issue in STEM is that teachers are not being trained properly. Qualified teacher training is an important step for STEM not to be emptied and to be integrated with the education system in a realistic way. Therefore, it is necessary to take steps that emphasize expertise in this regard and are carried out by experts. We regret that people who are not competent with projects on STEM education are providing so-called trainings and that these trainings cannot go beyond making money for some companies. The results we obtained from the report show that many projects under the name of teacher trainings are not at the desired level. Various institutions support interest projects with STEM trainings, but not enough attention is given to whether the people who will provide these trainings are experts in the field.

Another issue noted in the report to be spent in Turkey as well as the funding is avoided superfluous stems from both because of expensive materials. When it comes to STEM education, expensive materials that are usually imported come to mind. If we consider that every school cannot afford these materials, we will also see a fundamental difficulty in reaching STEM throughout Anatolia. It is important to pay attention to this fact during the establishment of the workshops indicated in the 2023 Education Vision Document, in terms of not wasting the material resources of our country.

Prominent findings and recommendations in the STEM Education Report

The most striking feature of the report is that it has given the issue for the world and STEM education as data when making suggestions about what needs to be done to put the current situation in Turkey is the main interlocutor and place the data obtained from teachers who are practitioners. So, this report in Turkey's overall profile of the ideal educator reflects the diversity and number of near level in accordance with the opinion of the teachers to the Ministry of Education and advising decision-makers in the field of education authorities. To be dealt with in the event of major milestone for Turkey in STEM education can be saved as another important feature of our report.

It is stated in our report that when STEM education is applied correctly, the quality of vocational high schools will increase, thus, the gap in intermediate staff in different sectors will be closed. It was emphasized that the importance of engineering and coding training and the need for in-service training for this and STEM should be included in the curricula of different departments in universities.

"STEM Teacher Institutes need to be created."

With the support of Development Agencies and TÜBİTAK, it was pointed out that the financial opportunities of the country should not be wasted on STEM education due to the fact that some trainings are not desired, and it is an important problem that STEM education in Education Faculties is not given enough as an important problem. The effect **of teachers** who could not get enough education in these fields in Education Faculties was pointed out in their failure according to their criteria. It was emphasized that STEM Teacher Institutes should be established in the report, which emphasizes that the delivery of STEM trainings not only by academicians and educators working in certain fields, but also by people working in different faculties and educational institutions will increase their quality.

In the report proposed to provide the necessary working environment on the basis of institutions for academicians and educators who are equipped and capable to catch Industry 4.0, it was suggested that education faculties should provide six years of education due to the long-term programs required by the STEM enriched curriculum. In relation to this aspect of the subject, it was also emphasized that graduate and doctorate programs focused on STEM education should be opened.

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List of topics in biotech innovation of interest in STEM education (as obtained by mixed working-tables -teachers and students- organised in each country by partners)

1. From Pythagorean tables to bio-inspired computing: a journey to discover biological-inspired computational algorithms.
2. From waste to clean resources: a virtuous bio-cycle for the creation of an eco-habitat.
3. Biomimicry: innovation and design inspired by Nature.
4. Bioarchitecture and bio-design: a multidisciplinary path across Art, Engineering and Science, driven by Nature.
5. Coronavirus emergency and biotechnology: from the thermo-scanner to the possible vaccine.
6. Home automation and bio-sustainability.
7. Bioengineering and artificial intelligence systems: what can we learn from natural behaviors?
8. From leaves photosynthesis to fuel cells.
9. Bio-inspired / smart health medicine.
10. Environmental education and biotechnology
11. Agricultural/food education and biotechnology
12. Marine (sea) education and biotechnology
13. Electric and magnetic phenomena in Bioengineering
14. Processing of big data, signals and images in Bioengineering
15. Bioengineering and tools for the study and design of medical devices and systems, natural and artificial materials, fabrics, apparatuses and agents
16. Methods of analysis of the characteristic structure-property link of biomaterials and biomechanical structures
17. Climate change
18. Industry 4.0 and biotechnology
19. Computer and information sciences (cryptology, programming, artificial intelligence, etc.)
20. Genetic Engineering
21. Neuroscience
22. Bioengineering and internet of things
23. Robotics in biotechnology field
24. Bio-technologies driven change
25. Game development, Arduino and coding

Survey results

After the identification of these 25 topics, we created two surveys in order to assess awareness and needs of the two target groups (teachers and students) and identify the "hottest" topics.

Students link:

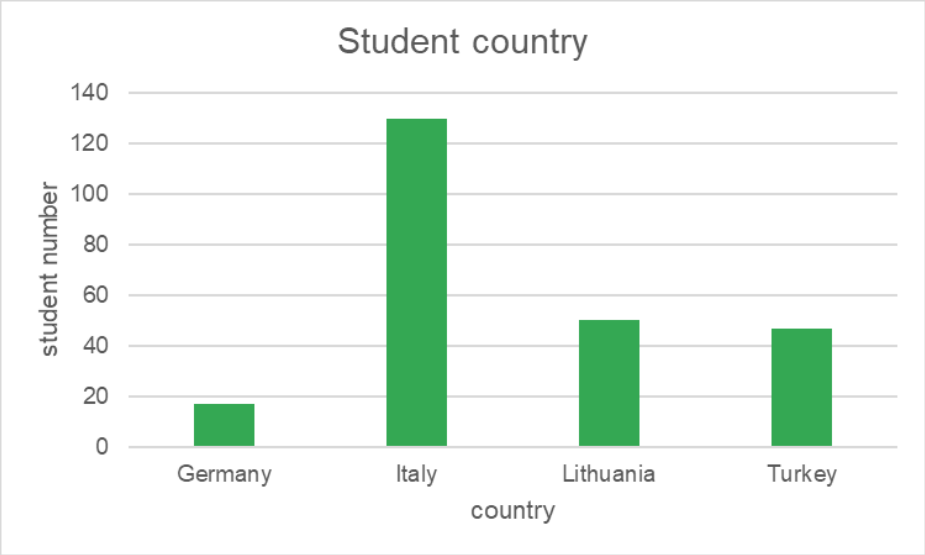
https://forms.gle/g3sZC8J6d31UwMdP9

Teachers Link:

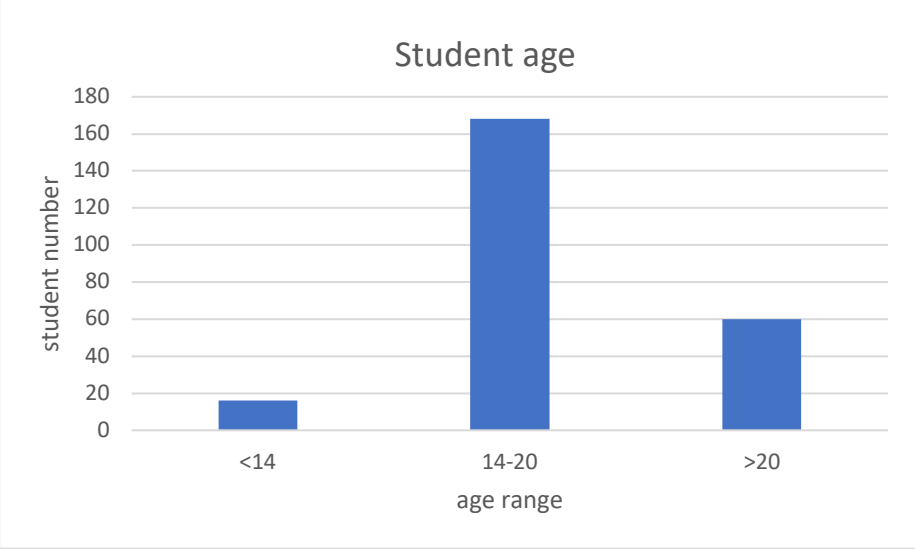
https://forms.gle/fymjgEXwypPuHFeL9

50 teachers and **244** students from the four Consortium countries participated in the study.

In the following we show the survey results:



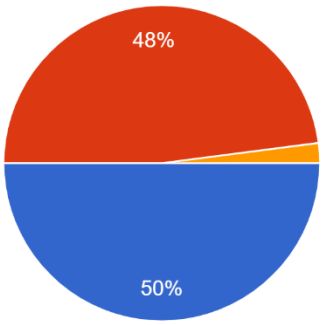
Country	Number of students
Germany	17
Italy	130
Lithuania	50
Turkey	47

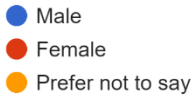


Age range	Number of students
<14	16
14-20	168
>20	60

Please write your gender

244 risposte



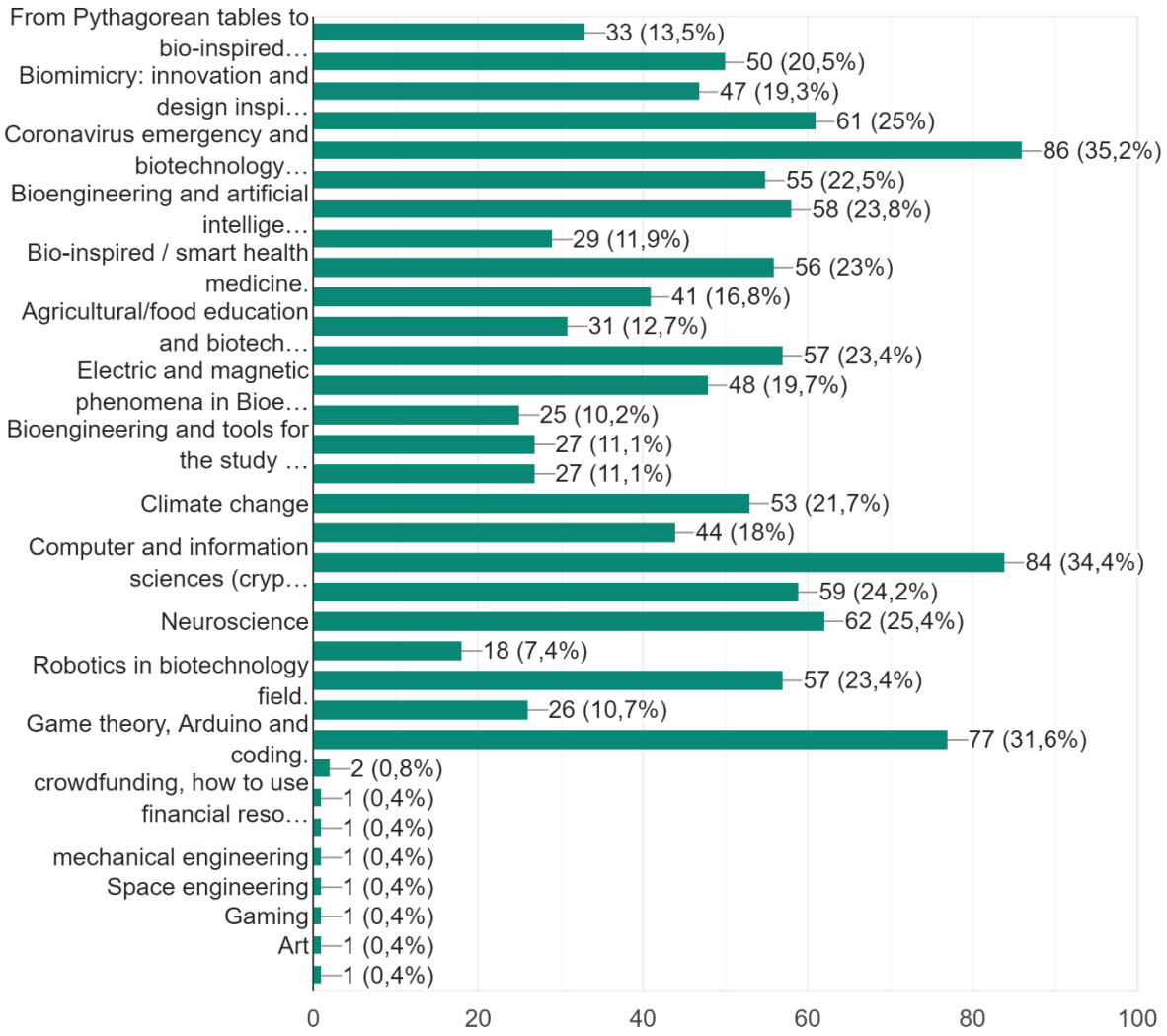


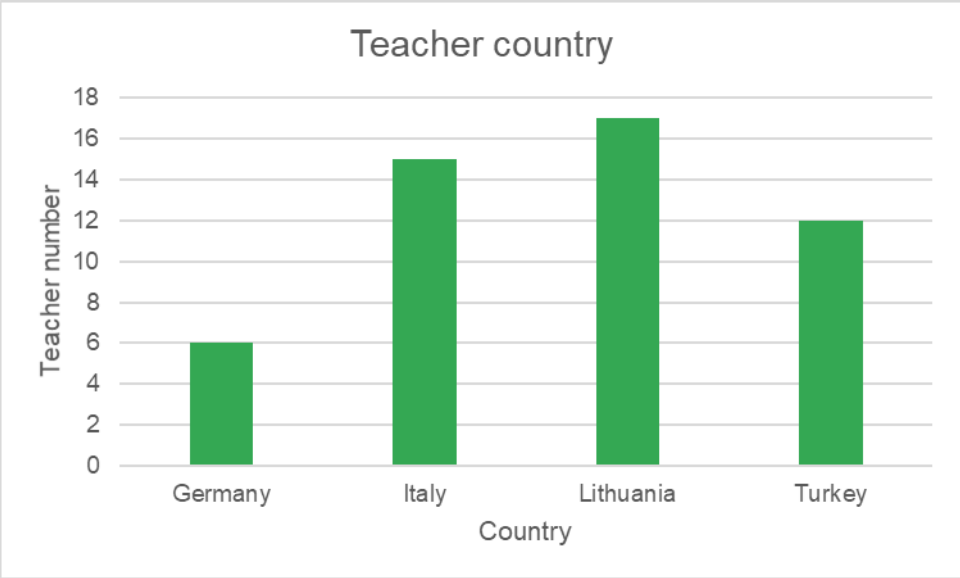
Gender	Number of students
Male	122
Female	117

	Selected topics	sudent number	Percent
1	Coronavirus emergency and biotechnology: from the thermo-scanner to the possible vaccine	86	35,2
2	Computer and information sciences (cryptology, programming, artificial intelligence, etc.)	84	34,4
3	Game development, Arduino and coding	77	31,6
4	Neuroscience	62	25,4
5	Genetic Engineering	59	24,2
6	Bioengineering and artificial intelligence systems: what can we learn from natural behaviors?	58	23,8
7	Robotics in biotechnology field	57	30
8	Marine (sea) education and biotechnology	57	28
9	Bio-inspired / smart health medicine	56	23
10	Home automation and bio-sustainability	55	22,5
11	Climate change	53	21,7
12	From waste to clean resources: a virtuous bio-cycle for the creation of an eco-habitat	50	20,5
13	Electric and magnetic phenomena in Bioengineering	48	19,7
14	Biomimicry: innovation and design inspired by Nature	47	19,3
15	Environmental education and biotechnology	41	16,8

Please, select the 5 most interesting topics for your education, which you would like to know more:

244 risposte

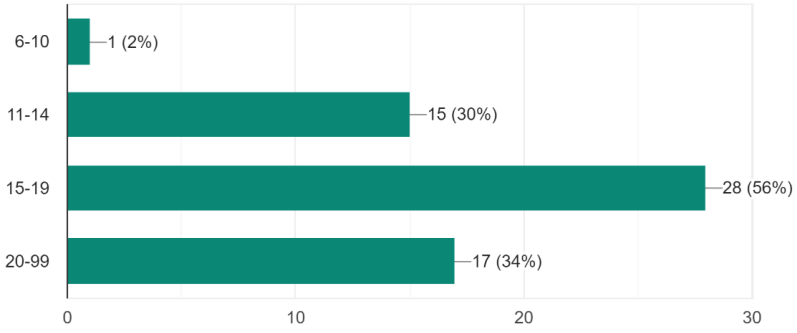




Country	Number of teachers
Germany	6
Italy	15
Lithuania	17
Turkey	12

Age range of your students

50 risposte



Student Age range	Number of teachers
6-10	1
11-14	15
15-19	28
20-99	17

	Selected topics	Teacher number	Percent
1	Climate change	18	36
2	Robotics in biotechnology field	17	34
3	Coronavirus emergency and biotechnology: from the thermo-scanner to the possible vaccine	16	32
4	Computer and information sciences (cryptology, programming, artificial intelligence, etc.)	16	32
5	From waste to clean resources: a virtuous bio-cycle for the creation of an eco-habitat	15	30
6	Biomimicry: innovation and design inspired by Nature	15	30
7	Game development, Arduino and coding	15	30
8	Bioengineering and artificial intelligence systems: what can we learn from natural behaviors?	14	28
9	Environmental education and biotechnology	13	26
10	Home automation and bio-sustainability	12	24
11	Electric and magnetic phenomena in Bioengineering	12	24

As we can note from different label colour, teacher selection is slightly different from student selection; in particular, more than 20% of teachers have chosen only three topics from the "red" selection in the student's best list and only three from the "yellow" selection.

With the aim to fit the needs of both "targets" of our project, the Consortium partners decide to adopt the student selection as the 15 "hottest" topics in biotech scientific innovation which could effectively engage the young learners by increasing their interest in STEM subjects. The forty national (10 in each national language) and 5 transnational teaching/learning modules should be created on these topics; furthermore, the topic for the 5 transnational learning environment (one for each partner) should be selected within the "red" selection, but this is not mandatory. More important, it is hoped that most teaching/learning paths will be multidisciplinary and incorporate two or more of these topics.

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