D3.1 Report on desk research

Report

(Public)

Project Acronym: EDU-ARCTIC

Project Title:

"Edu-Arctic – Innovative educational program attracting young people to natural sciences and polar research"

NUMBER — 710240 — EDU-ARCTIC

Document information summary

Date:	1st submission: 30 June 2016, 2nd submission: 19 July 2016 (updated)
Leader Partner:	American Systems Sp. z o.o.
Main Authors:	Krzysztof Man
Reviewed by:	Agata Goździk, Maria Korda
Target audience:	Consortium members, REA/European Commission (EC), other interested parties
Delivery date:	M2
Version:	7.

This project (EDU-ARCTIC) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 710240.

TABLE OF CONTENTS:

Executive summary

The current report concerns Deliverable D3.1 *Desk research*. The report is a first guide for the Consortium Beneficiaries and EDU-ARCTIC itself, as an EU funded Project, on the EDU-ARCTIC's Program, where the social and educational point of view is the *key objective* of Work Package 3. In particular, the report provides guidance on understanding Science, Technology, Engineering and Mathematics (STEM) basic skills as well as labour market and scientific environment needs. In addition, it aims to assist the understanding of the current approaches in methods of encouraging young people to pursue careers in STEM, labour market needs in the field of science and STEM professions, relevant policies, strategies, programmes, objectives and recommendations.

The report is based on the results gathered from the recent reports of many European institutions that focus on education in STEM; especially, science as well as certain specific key competencies. The aforementioned reports include a comprehensive review of the scientific literature, documents relating to national policies and international research results.

There are eight key competences set out at an EU level[1]. They consists of combination of knowledge, skills and attitudes that are being considered as necessary for personal fulfilment, development, active citizenship, social inclusion and employment:

1. Communication in the mother tongue;
2. Communication in foreign languages;
3. Mathematical competence and basic competences in science and technology;
4. Digital competence;
5. Learning to learn;
6. Social and civic competences;
7. Sense of initiative and entrepreneurship;
8. Cultural awareness and expression.

The current report does not include all the above mentioned key competences. It is only focused on STEM, and mainly science education (SE). The above given competences in science are solid part of the Reference Framework.

To a large extent, this EDU-ARCTIC *Desk research* is based on information stemming from the following reports:

- SCIENCE EDUCATION for Responsible Citizenship - Report To The European Commission Of The Expert Group On Science Education (2015), http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf ;
- Efforts To Increase Students' Interest In Pursuing Science, Technology, Engineering And Mathematics Studies And Careers - National Measures taken by 30 Countries – 2015 Report, C. Kearney, http://www.dzs.cz/file/3669/kearney-2016-nationalmeasures-30-countries-2015-report-28002-29-pdf/ ;

[1] RECOMMENDATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006 on key competences for lifelong learning (2006/962/EC), http://www.atee1.org/uploads/EUpolicies/key_competences_for_lll_final_dec2006.pdf, 15.06.2016.

- Description Of STEM Knowledge Networks In Europe (2016) http://onderwijs.vlaanderen.be/sites/default/files/atoms/files/Description%20of%20STEM%20knowledge%20networks%20in%20Europe.pdf ;
- Responsible Research and Innovation (RRI), Science and Technology (2013) – Report conducted by TNS Opinion & Social at the request of the European Commission, Directorate-General for Research & Innovation, http://ec.europa.eu/public_opinion/archives/ebs/ebs_401_en.pdf ;
- Encouraging STEM studies. Labour Market Situation and Comparison of Practices Targeted at Young People in Different Member States (2015), http://www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU(2015)542199_EN.pdf ;
- Skills For The Labour Market (2015) - European Semester Thematic Fiche, http://ec.europa.eu/europe2020/pdf/themes/2015/skills_for_labour_market_20151126.pdf
- A New Method to Understand Occupational Gender Segregation in European Labour Markets (2014), http://ec.europa.eu/justice/gender-equality/files/documents/150119_segregation_report_web_en.pdf ;
- Applying STEM Instructional Strategies to Design and Technology Curriculum (2014), http://www.ep.liu.se/ecp/073/013/ecp12073013.pdf ;
- International Standard Classification of Occupations, Structure, group definitions and correspondence tables, International Labour Office, Geneva, 2012, https://www.cbs.nl/NR/rdonlyres/B30EE525-22DB-4C1B-B8D5-6D12934AF00A/0/isco08.pdf;
- The Supply of and Demand for High-Level STEM Skills, Evidence Report 77 (2013), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/302973/evidence-report-77-high-level-stem-skills_1_.pdf ;
- Eurydice: Science Education in Europe: National Policies, Practices and Research. Education, Audiovisual and Culture Executive Agency, Brussels (2011), http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/133en.pdf ;
- European Commission/EACEA/Eurydice, Developing Key Competences at School in Europe: Challenges and Opportunities for Policy. Eurydice Report. Luxembourg: Publications Office of the European Union (2012), http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/145en.pdf ,

Some further reports are equally being cited for further reference.

The final part of the *Desk research* presents the results of the CAWI Survey (Computer Assisted Web Interview) that has been issued among the Consortium Beneficiaries. The prepared questions form one of the key sources on which it was prepared and a valid point in the broad subject of STEM among the consortium Beneficiaries. CAWI has been prepared in English.

This *Desk research* focuses on the understanding of STEM among the Beneficiaries and helps to achieve the objectives as set out within the Work Package 3 – *Preparatory of EDU-ARCTIC Program*. This *Desk research* is the first step for the preparation of recommendations for the *EDU-ARCTIC program*. It stresses the needs and approaches in STEM education at national and EU level. It also provides useful literacy for the Beneficiaries, which is needed for the proper program development of the *EDU-ARCTIC program*. Materials presented in this document, together with the project's

Deliverable3.2 *Report on requirement analysis* (due in month 4) will be further analysed and used for preparation of the Deliverable 3.3 *Recommendations for EDU-ARCTIC Program*.

1. Introduction

Over the past 20 years, there has been growing interest in science education in most European countries, as well as around the world. Such policies usually have a dual purpose: to promote science literacy among all young people (and even adults) and attract young people to science and the disciplines of technology in secondary and higher education, with the aim of encouraging them to move to science and technology professions and/or research-scientific careers. The primary reason for this was the global shortage of science graduates. At the same time, increased attention was paid to science education for girls and young people with vulnerable socio-economic backgrounds[2].

According to the European Schoolnet (EUN),[3] skills in science, technology, engineering and mathematics (STEM) are becoming an increasingly important part for basic literacy in today's knowledge economy. ***There is a need for one million additional researchers by 2020 in order to keep the Europe growing[4]***. Science education can no longer be viewed as only elite training for future scientists or engineers. It is clearly visible that only science-aware citizens can make informed decisions and engage in dialogue on science-driven societal issues. As stated in the recent Report of the European Commission (EC) – *Science Education for Responsible Citizenship,* knowledge of and about science are integral to preparing our population to be actively engaged and responsible citizens, creative and innovative, able to work collaboratively and fully aware of and conversant with the complex challenges facing society[5].

2. What is STEM?

Acronym STEM refers to the academic disciplines of Science that captures the areas of science, technology, engineering and mathematics. STEM adheres to the development of scientific, technological and mathematical insights, concepts and practices and how to use and apply them in practice in order to solve complex questions or real-life challenges. Therefore, within the broader education context, STEM implies bringing together the different components of the acronym to identify social and scientific challenges in a coherent manner, solving them in an inquiry-based manner and communicating about them. STEM also implies that the various disciplines are taught in the best possible way[6].

---

[2] DESCRIPTION OF STEM KNOWLEDGE NETWORKS IN EUROPE, http://onderwijs.vlaanderen.be/sites/default/files/atoms/files/Description%20of%20STEM%20knowledge%20networks%20in%20Europe.pdf, 15.06.2016.

[3] European Schoolnet (EUN) is a network of 31 Ministries of Education from across the European member states, leading educational innovation at Europen level. As a not-for-profit organisation, European Schoolnet aims to bring innovation in teaching and learning to key stakeholders: Ministries of Education, schools, teachers, researchers, and industry partners. Focus areas: Innovation, STEM, eSafety. Main activities: schools support, teachers trainings, collaboration with teachers. *See in detail via: http://www.eun.org/home.*

[4] European Schoolnet, STEM, http://www.eun.org/focus-areas/stem, 15.06.2016.

[5] SCIENCE EDUCATION for Responsible Citizenship, http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf, 29.06.2016.

[6] STEM Framework for Flemish Schools Principles and Objectives, http://onderwijs.vlaanderen.be/sites/default/files/atoms/files/STEM-kader%20%28Engels%29.pdf, 15.06.2016.

STEM or science only, is being seen as something separate from all other subjects or disciplines in education, disconnected from people's lives beyond school. It has been proven that science influences all parts of our lives and our decision-making processes. Along with language and artistic literacy, knowledge of science and mathematics is the basis for personal accomplishment and responsible citizenship, social and economic development and a benchmark of innovation, entrepreneurship and competitiveness in our global world[7].

Therefore STEM ensures that important scientific, mathematical, technological and engineering-linked concepts and practices are understood and applied in an interdisciplinary manner. This shows that these concepts and practices are founded on STEM principles and ideas that can be applied from various angles. STEM is oriented towards innovation: it responds to current challenges and looks for innovative and creative solutions through the interconnected STEM components.

STEM policy at school involves customization, which means it is tailored to the specific initial situation and context. It selects themes, objectives, actions, methodologies and materials which tie in as closely as possible with the specific initial situation and the school's policy choices. STEM shows that new developments in science and technology, as well as social challenges, require cooperation from various domains. That is why the present STEM framework not only focuses on the content-related dimensions of STEM, but also seeks to recognize the STEM Learning Networks[8].

3. Why Science Education and STEM are so important?

There are many reasons why knowledge of science is a *key element* for European policy and policy-making in general.

First of all, it prepares citizens and involves them in different creative and innovative actions. It allows working collaboratively and being fully aware of and conversant with the complex challenges faced nowadays by our societies.

It helps explaining and understanding the world around us and enables us to make more accurate forecasts and future planning. Finally it helps in the formalization of citizens involved in an active way and building a European culture.

According to the recent Report of the European Commission (EC) – *Science Education for Responsible Citizenship* – composed by the,[9] it is vital:

- To promote a culture of scientific thinking and inspire citizens to use evidence-based reasoning for decision making;
- To ensure citizens have the confidence, knowledge and skills to participate actively in an increasingly complex scientific and technological world;

[7] SCIENCE EDUCATION for Responsible Citizenship, http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf, 15.06.2016.
[8] STEM Framework for Flemish Schools Principles and Objectives, http://onderwijs.vlaanderen.be/sites/default/files/atoms/files/STEM-kader%20%28Engels%29.pdf, 15.06.2016.
[9] SCIENCE EDUCATION for Responsible Citizenship, http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf, 15.06.2016.

- To develop the competencies for problem-solving and innovation, as well as analytical and critical thinking that are necessary to empower citizens to lead personally fulfilling, socially responsible and professionally-engaged lives;
- To inspire children and students of *all ages and talents* to aspire to careers in science and other occupations and professions that underpin our knowledge and innovation-intensive societies and economies, in which they can be creative and accomplished;
- To enable public, private and third-sector organisations, based in Europe, to find appropriately skilled and knowledgeable people and to promote and nurture an innovative Europe wide environment where companies and other stakeholders from around the world want to invest, work and live;
- To empower responsible participation in public science conversations, debates and decision-making as active engagement of European citizens in the big challenges facing humanity today.

According to the report conducted by TNS Opinion & Social – at the request of the European Commission, Directorate-General for Research & Innovation[10] – science education allows us to interpret and understand our world, to manage risk and put uncertainty into perspective, to guide technological development and innovation and to forecast and plan for the future. It improves job prospects, cultural awareness and our ability to act as well-informed citizens in solidarity with citizens around the world.

STEM is about education and the labour market. Young people have to make choices at certain moments in their school careers. Therefore, it is crucial to show them the wide range of opportunities, to help them make these choices and to point out to them the inextricable link between various professions in a highly technological and scientific knowledge society. Therefore, STEM furthers the knowledge and technology intensive economy by assisting young people in their search[11].

The EC Science Education Expert Group within the report *Science Education for Responsible Citizenship*[12] approaches this at a much bigger scale:

- STEM competencies are essential for being able to function in the 21st century, with more attention being paid to inquiry-based learning and working, links between knowledge and practice, problem-solving skills, creative out-of-the-box thinking, cooperation, etc.);
- STEM has a very broad purpose in professional life. It concerns both 'direct' and 'indirect' STEM jobs;
- Great potential remains in a number of target groups which currently still have too few STEM competencies and do not sufficiently avail themselves of STEM opportunities.

[10] Responsible Research and Innovation (RRI), Science and Technology (2013), http://ec.europa.eu/public_opinion/archives/ebs/ebs_401_en.pdf, 15.06.2016.
[11] STEM Framework for Flemish Schools Principles and Objectives, http://onderwijs.vlaanderen.be/sites/default/files/atoms/files/STEM-kader%20%28Engels%29.pdf, 15.06.2016.
[12] SCIENCE EDUCATION for Responsible Citizenship, http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf, 15.06.2016.

4. Objectives and Recommendations

The EC *Science Education for Responsible Citizenship* report[13] provides the main objectives and recommendations towards science education and STEM. These are the six high-level objectives of the Framework for Science Education for Responsible Citizenship.

Objectives are taken directly from the report, in order to ensure that the context has not been altered:

1. *Science education should be an essential component of a learning continuum for all, from pre-school to active engaged citizenship.*
   Therefore education policies and systems should:
   - Ensure that science is an essential component of compulsory education for all students;
   - Support schools, teachers, teacher educators and students of all ages to adopt an inquiry approach to science education as part of the core framework of science education for all;
   - Address socio-economic, gender and cultural inequalities in order to widen access and provide everyone with the opportunities to pursue excellence in learning and learning outcomes;
   - Create mechanisms to foster individual reflection and empowerment.
2. *Science education should focus on competences with an emphasis on learning through science and shifting from STEM to STEAM by linking science with other subjects and disciplines (In STEAM - A includes ALL other disciplines).*
   Educational institutions, at all levels, should boost understanding the importance of science education as a means of acquiring key competences to ease the transition from "education to employability" (E2E), by:
   - Learning about science through other disciplines and learning about other disciplines through science;
   - Strengthening connections and synergies between science, creativity, entrepreneurship and innovation.

   More emphasis should be placed on ensuring all citizens are equipped with the skills and competences needed in the digitalized world starting with preschool.

3. *The quality of teaching, from induction through pre-service preparation and in-service professional development, should be enhanced to improve the depth and quality of learning outcomes.*
   - Actions should be taken to continually improve teaching quality, with greater focus on teacher competences, disciplinary knowledge, avoiding gender stereotyping and on students and teachers learning together;
   - Efforts should be undertaken to attract more highly qualified and motivated people to become teachers and to boost the status and prestige of the profession;

[13] SCIENCE EDUCATION for Responsible Citizenship, http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf, 15.06.2016.

- Greater emphasis should be given to closing the research-practice gap, by embedding science education research findings into teacher preparation, curriculum development, teaching and learning and assessment for learning;
- Appropriate methodologies should be developed for teaching research ethics and raising awareness of research integrity;
- Continuous Professional Development (CPD) should become a requirement and a right for all teachers throughout their teaching career.

4. *Collaboration between formal, non-formal and informal educational providers, enterprise and civil society should be enhanced to ensure relevant and meaningful engagement of all societal actors with science and increase uptake of science studies and science-based careers to improve employability and competitiveness.*
    - The main important is to promote partnerships between teachers, students, researchers, innovators, professionals in enterprise and other stakeholders in science-related fields, in order to work on real-life challenges and innovations, including associated ethical and social and economic issues
5. *Greater attention should be given to promoting Responsible Research and Innovation (RRI) and enhancing public understanding of scientific findings and the capabilities to discuss their benefits and consequences.*
    - The link between scientists, researchers, science educators and the media should be strengthened to ensure more effective public communication, in a way that makes the underlying issues and consequences understandable by citizens;
    - Science educators, at all levels, have a responsibility to embed social, economic and ethical principles into their teaching and learning in order to prepare students for active citizenship and employability;
    - Publicly-funded science education researchers have a responsibility to openly communicate, share and disseminate research outcomes with wider society and to the international research community;
    - Citizens should be actively and directly involved in science research and innovation projects.
6. *Emphasis should be placed on connecting innovation and science education strategies, at local, regional, national, European and international levels, taking into account societal needs and global developments.*
    - Links between Responsible Research and Innovation strategies at local, regional and national level should be strengthened and evaluated in order to overcome regional and other disparities across Europe and to increase the innovation capabilities of enterprise, particularly SMEs;
    - Collaborating and sharing knowledge of and about science and science communication, as well as identifying solutions for global societal challenges facing humankind, should be actively pursued with international partners;
    - Science education should benefit from an agreed set of international guidelines, evidence-based and grounded on collaborative and inclusive deliberations.

5. STEM Professionals and associate professionals

A study proposed in The Supply of and Demand for High-Level STEM Skills (2013)[14], identified 30 STEM occupations – those occupations which utilise most STEM skills. These ranged from mathematicians, chemists, computer hardware engineers and civil engineers, to astronomers, agricultural and food science technicians and statisticians.

All 30 occupations fit into the occupational categories defined in the INTERNATIONAL STANDARD CLASSIFICATION OF OCCUPATIONS (ISCO-08)[15].

These are: science and engineering professionals (ISCO/SOC 21), information and communications technology professionals (ISCO/SOC 25), and science and engineering associate professionals (ISCO/SOC 31 and 35).

Science and engineering professionals:
Main activities: 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, pharmacology, medicine, mathematics, statistics, architecture, engineering, design and technology.

Occupations in this group are classified into the following minor groups:

- ***Physical and Earth Science Professionals***
  Examples: Astronomer, Medical physicist, Nuclear physicist, Physicist, Climatologist Hydrometeorologist, Meteorologist, Weather forecaster, Chemist, Biochemist, Geological Oceanographer, Geologist, Geophysicist, Geoscientist, etc.;
- ***Mathematicians, Actuaries and Statisticians***
  Examples: Actuary, Demographer, Mathematician, Statistician, Operations research analyst, etc.;
- ***Life Science Professionals***
  Examples: Animal behaviourist, Bacteriologist, Biologist, Biomedical researcher, Biotechnologist, Botanist, Microbiologist, Zoologist, Molecular geneticist, Molecular biologist, Agronomist, Soil scientist, Fisheries adviser, Forestry adviser, Forestry scientist, Air pollution analyst, Ecologist, Park ranger, Water quality analyst, Conservation scientist, Environmental adviser, Environmental research scientist, etc.;
- Engineering Professionals
  Examples: Industrial efficiency engineer, Industrial engineer, Industrial plant engineer, Production engineer, Civil engineer, Geotechnical engineer, Structural engineer, Metallurgist, Aeronautical engineer, Engine designer, Mechanical engineer, Chemical engineer, Fuel

[14] The Supply of and Demand for High-Level STEM Skills, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/302973/evidence-report-77-high-level-stem-skills_1_.pdf, 25.06.2016.
[15] International Standard Classification of Occupations, https://www.cbs.nl/NR/rdonlyres/B30EE525-22DB-4C1B-B8D5-6D12934AF00A/0/isco08.pdf, 25.06.2016.

technologist, Plastic technologist, Refinery process engineer, Extractive metallurgist, Nuclear power generation engineer, Quantity surveyor, etc.;

- ***Electrotechnology Engineers***
  Examples: Electric power generation engineer, Electromechanical engineer, Computer hardware engineer, Electronics engineer, Instrumentation engineer, Telecommunications engineer, Broadcast engineer, etc.;
- ***Architects, Planners, Surveyors and Designers***
  Examples: Building architects, Interior architects, Landscape architects, Urban planner, Costume designer, Fashion designer, Industrial designer, Jewellery designer, Land planner, Aerial surveyor, Cadastral surveyor, Cartographer, Computer games designer, Digital artist, Graphic designer, Multimedia designer, Website designer, etc.

Information and communications technology professionals:
Main activities: conduct research, plan, design, write, test, provide advice and improve information technology systems, hardware, software and related concepts for specific applications; develop associated documentation including principles, policies and procedures; and design develop, control, maintain and support databases and other information system to ensure optimal performance, data integrity and security,

<u>*Occupations in this group are classified into the following minor groups:*</u>

- ***Software and Applications Developers and Analysts***
  Examples: Computer scientist, Information system analyst, System designer (IT), Business analyst (IT), Programmer analyst, Software designer, Software developer, Software engineer, Website developer, Website architects, Multimedia programmer, Applications programmer, Software tester, Quality assurance analyst (IT), etc.;
- ***Database and Network Professionals***
  Examples: Data administrator, Database administrator, Database analyst, Database architect, Network administrator, Systems administrator (IT), Network analyst, Digital forensic specialist, etc.

Science and engineering associate professionals:
Main activities: perform technical tasks connected with research and operational methods in science and engineering. They supervise and control technical and operational aspects of mining, manufacturing, construction and other engineering operations and operate technical equipment including aircraft and ships.

<u>*Occupations in this group are classified into the following minor groups:*</u>

- Physical and Engineering Science Technicians;
- Mining, Manufacturing and Construction Supervisors;
- Process Control Technicians;
- Life Science Technicians and Related Associate Professionals;
- Ship and Aircraft Controllers and Technicians.

Also to associate professionals are included: **Information and communications technicians.** They provide support for the day-to-day running of computer systems, communications systems and networks, and perform technical tasks related to telecommunications, broadcast image and sound as well as other types of telecommunications signals on land, sea or in aircraft.

Occupations in this group are classified into the following minor groups:

- Information and Communication Technology Operations and user Support Technicians;
- Telecommunications and Broadcasting Technicians.

6. The labour market situation in STEM-related jobs

According to the document requested by the European Parliament's Committee on Employment and Social Affairs: Encouraging STEM studies (2015),[16] employment of STEM skilled labour in the EU is increasing in spite of the economic crisis, and demand is expected to grow.

In parallel, high numbers of STEM workers are approaching retirement age. Around 7 million job openings are forecasted until 2025 - two-thirds for replacing retiring workers.

- Employment of STEM professionals and associate professionals in the EU was approximately 12% higher in 2013 than it was in 2000;
- Demand for STEM professionals and associate professionals is expected to grow by 9% between 2015 and 2025, whilst the average growth forecast for all occupations is 3%;
- Employment forecast in STEM-related sectors shows a similar trend: it is estimated to rise by 6.5% between 2013 and 2025, although with huge differences across sectors. Whilst zero employment growth is expected in the pharmaceuticals sector, employment is expected to rise by 8% in computing and by 15% in professional services;
- Demand for STEM skills concerns both upper-secondary and university graduates. Currently almost half of the STEM occupations require medium-level qualifications and this trend is expected to persist;
- Concerns about the supply of STEM skills rely on two basic facts: the proportion of students going into STEM is not increasing at the European level and the underrepresentation of women persists. So far, these trends have been mitigated by the expansion of higher education, which has led to an increase in the absolute numbers of STEM university graduates in the European Union since the mid-2000s. The number of STEM VET graduates has nevertheless decreased;
- A large majority of Member States have experienced recent recruitment difficulties in relation to STEM skilled labour. Shortages appear to be more pronounced for technological occupations (engineering and ICT) and professionals. Challenges arise from insufficient number of graduates and a lack of experienced staff;
- The unemployment rate for STEM skilled labour has been very low and well below the total unemployment rate since the beginning of the 2000s, even in countries particularly hit by the crisis, such as Greece, Portugal and Spain. This fact shows the high demand for workers with these skills. In 2013, the STEM unemployment rate was as low as 2%, whilst the total

[16] Encouraging STEM studies (2015), http://www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU(2015)542199_EN.pdf, 20.06.2016.

unemployment rate was 11%. This fact shows the high demand for workers with STEM skills, with unemployment just reflecting workers moving or changing jobs.

Current (2015) and anticipated employment demand in key STEM-related occupations, EU-28, 2015-2025[17]:

STEM Professionals	2015	2025	Change 2015-2025
Science and engineering professionals	4,420,000	5,086,000	13%
Science and engineering associate professionals	10,666,000	11,434,000	7%
All occupations	227,072,000	234,340,000	3%

According to the document prepared for the use of the EC, Directorate-General for Justice; Unit D2: Equality between men and women: A New Method to Understand Occupational Gender Segregation in European Labour Markets (2014)[18], employment in STEM is male-dominated. Women account for just 24% of science and engineering professionals and 15% of science and engineering associate professionals.

7. Methods of encouraging careers in STEM

Researchers have identified different social, cultural and economic factors to explain the shortages in young people's engagement with STEM subjects and careers. Factors related to different education systems have been also taken into consideration. Finally, attention has been paid to persisting gender differences in the choice of study field and the underrepresentation of women among STEM graduates[19]. As Dobson argues, differences in STEM are also related to the economic structure and the educational policies[20]. Connie l. Mcneely proves that the higher standards of living among young people, the lower interest in STEM careers[21].

---

[17] Science, technology, engineering and mathematics (STEM) skills, http://skillspanorama.cedefop.europa.eu/sites/default/files/EUSP_AH_STEM_0.pdf, 25.06.2016.
[18] A New Method to Understand Occupational Gender Segregation in European Labour Markets (2014), http://ec.europa.eu/justice/gender-equality/files/documents/150119_segregation_report_web_en.pdf, 15.06.2016.
[19] Encouraging STEM studies (2015), http://www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU(2015)542199_EN.pdf, 20.06.2016
[20] STEM: Country Comparisons International comparisons of science, technology, engineering and mathematics (STEM) education (Marginson, Tytler, Freeman & Roberts), http://www.academia.edu/3664766/STEM_Country_Comparisons_International_comparisons_of_science_technology_engineering_and_mathematics_STEM_education_Marginson_Tytler_Freeman_and_Roberts_, 20.06.2016.
[21] The Global Chase for Innovation: Is STEM Education the Catalyst?, http://www.globality-gmu.net/archives/2972, 22.06.2016.

The list of factors has been directly taken from the document: Encouraging STEM studies[22] in order to ensure that the context has not been changed:

- Social factor – the level of interest, knowledge and understanding of science issues embedded in the pupil's immediate environment (family and friends);
- Cultural factors – the existence of a changing attitude of society toward science and technology has been pointed out. This trend is also related to the emergence of a more pessimistic vision that rejects the belief that “the future should be better than the past” and “that everything can and should be improved”;
- Economic and working conditions factors – STEM studies are said to report higher private returns on education (employment prospects and salaries of graduates) than many other study fields;
- Educative institutional factors – It has been noted that the way in which science subjects are taught has a great influence on students' attitudes towards science and on their motivation to study and, consequently, their achievement;
- Gender-related factors – Persisting gender segregation across study fields is the result of a mix of social, cultural, economic and educational institutional factors[23]. The literature highlights the role of gender socialization of boys and girls to explain their uneven distribution across study fields. Family and especially parents play a key role as they often bring up their children to conform to traditional gender roles, while the education system, teachers and peers, tend to reinforce these stereotypes, giving support to gendered choices with regard to studies and career prospects.

There are three[24] main policy approaches related to encouraging STEM studies and careers in Europe:

1. curricular and teaching methods;
2. teacher professional development;
3. guiding young people to STEM.

Amanda Roberts and Diana Cantu at document: Applying STEM Instructional Strategies to Design and Technology Curriculum,[25] provide also with other approaches:

4. The Silo Approach – refers to isolated instruction within each individual STEM subject. The disciplines are taught separately, which keeps the domain knowledge within the confines of each discipline. Emphasis is placed on “knowledge” acquisition as opposed to technical ability. Concentrated study of each individual subject allows the student to gain a greater depth of understanding of course content. Students are provided little opportunity to “learn by doing” rather they are taught what to know.

---

[22] Encouraging STEM studies (2015), http://www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU(2015)542199_EN.pdf, 20.06.2016.

[23] For more visit: Meta-analysis of gender and science research, https://ec.europa.eu/research/swafs/pdf/pub_gender_equality/meta-analysis-of-gender-and-science-research-synthesis-report.pdf, 20.06.2016.

[24] Encouraging STEM studies (2015), http://www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU(2015)542199_EN.pdf, 20.06.2016.

[25] Applying STEM Instructional Strategies to Design and Technology Curriculum, http://www.ep.liu.se/ecp/073/013/ecp12073013.pdf, 20.06.2016.

5. The Embedded Approach – may be broadly defined as an approach to education in which domain knowledge is acquired through an emphasis on real-world situations and problem-solving techniques within social, cultural, and functional contexts. In practice, embedded teaching is effective instruction because it seeks to reinforce and complement materials that students learn in other classes. A technology education teacher uses embedding to strengthen a lesson which benefits the learner through understanding and application.
6. The Integrated Approach – that approach to STEM education envisions removing the walls between each of the STEM content areas and teaching them as one subject. Integration enables a student to gain mastery of competencies needed to resolve a task.

Other methods and teacher practices must be taken into consideration, and in particular:[26]

7. Transfer control of the learning process to the students. Develop new roles and rules that stress student responsibility;
8. Foster curiosity. Learn the art of asking open-ended questions with plenty of possible answers. Pose problems rather than answers and send students on a search for solutions;
9. Provide hands-on, experiential learning;
10. Increase collaboration among students. Get comfortable with teamwork. Actively teach teamwork skills and work with students to heighten awareness of their team behaviours and ways of interacting in the class;
11. Accept failure – both the teacher and the students – as a necessary part of learning and growing. That is, accept failure that accompanies taking a risk and experimenting, knowing that they might not get it right;
12. Teacher/educator should be an inspiring leader and role model for his/her students. Be positive and enthusiastic about what students are learning and how they are learning it. Be passionate in teaching and love subject area;
13. Accept some drawbacks. STEM education will improve student engagement, critical thinking skills, and workforce skills;
14. Evolve and grow as a learner. One of the most important things STEM educator can do is to pay attention to the art of teaching;
15. Learn in community. Work with colleagues to study effective ways of teaching STEM lessons.

8. Selected national practices to encourage STEM

Below certain initiatives are presented, which serve as good examples of relevant practices in the field of the active labour market policies in European countries. These initiatives have also a huge impact on increasing the supply of skilled labour in STEM fields:

1. **Portugal:** In 2014 New Technology-focused Higher Education short courses were established by the Ministry of Higher Education in order to amplify the range of options offered by polytechnics. These are level-five higher education courses that have strong links to the labour market, specifically in terms of the local and regional economy. The target group for these courses are graduates from upper-secondary vocational education and adults;

[26] 10 STEM Teaching Practices (2013), http://www.middleweb.com/6624/10-stem-teaching-practices/,20.06.2016.

2. **Denmark:** The continuing education of teachers in public schools was the target of the Danish Government. The objective of the initiatives was to provide teachers with a specialisation in science or mathematics – although other specialisations could be also followed. During the three year implementation period, more than 800 teachers gained a science subject specialisation. 430 teachers also finished courses which qualified them to be science guidance counsellors;
3. **UK (Eng):** England rolled out The Transition to Teaching Programme which was targeted at those wanting to change career to teach at the secondary school level in mathematics, science or information and communication technology (ICT). Its target group was those with STEM qualifications at the degree level who could also provide a recommendation by an employer. Enhancement courses were also offered. Their main aim was to enable graduates, wanting to teach physics, maths or chemistry - to develop sufficient subject knowledge to teach secondary level pupils;
4. **France:** In July 2013 France passed laws to restructure schools and to regulate the field of higher education and research. One of the measures included in the laws aims specifically to encourage and facilitate access to short cycles of higher education for those VET students who graduate with honours;
5. **EU**: inGenious[27] is one of the largest and most strategic projects in science education funded by the European Commission. inGenious aims to increase young Europeans' interest in STEM education and careers, addressing two challenges: lack of interest in STEM subjects and future skills gaps[28]. The "Innovative Practices for Engaging STEM teaching"[29] course (part of the project InGenious) aimed to provide teachers, school counsellors and career advisers with resources and ideas to increase pupils' interest for STEM subjects and careers. The course was structured into 8 modules which develop a learning path from the analysis of the reasons behind pupils' disaffection for STEM to the development and experimentations with innovative practices to overcome it. Modules were: 1- Increasing student's engagement to study STEM, 2- Original teaching practices in the STEM classroom, 3- Innovative STEM teaching: using STEM resources from across Europe, 4 - Discovering virtual & remote labs and how to use them in the classroom, 5 - Exploring STEM in the real world - Virtual visits to research centers, 6 - Helping students to understand what STEM jobs are - Career counselling, 7 - Meeting real life STEM professionals, 8 - Dealing with stereotypes. Some of the inGenious major achievements: Network of 340 inGenious Pilot teachers, extended network of over 1500 inGenious teachers, collection of 158 school-industry collaboration practices, a network of over 40 partners and associate partners ready to help schools and teachers, teachers and students evaluation of 34 school-industry practices[30].

[27] Further information is available via: http://www.ingenious-science.eu/web/guest, 22.06.2016.
[28] Encouraging STEM studies (2015), http://www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU(2015)542199_EN.pdf, 20.06.2016.
[29] http://www.europeanschoolnetacademy.eu/web/innovative-practices-for-engaging-stem-teaching, 25.06.2016.
[30] http://www.ingenious-science.eu/web/guest, 22.06.2016.

9. STEM projects

There are many examples of well-prepared science education practices across Europe. These can be taken as valid ideas for new initiatives and could be easily adopted based on the project's needs.

Below a list of projects is provided, divided by projects founded under the Seventh Framework Programme (FP7)[31] and other projects where STEM is key element.

8.1 Examples of selected FP7 projects[32]

Selected examples of FP7 projects are aligned to the six high-level objectives of the Framework for Science Education for Responsible Citizenship[33]. These examples could be an inspiration for teachers, trainers, educators, enterprise, social organisations and policy-makers to promote responsible science education. They may be also inspiring for the EDU-ARCTIC beneficiaries in the process of its educational program development, as well as for networking activities.

FP7 was the EU's Research and Innovation funding programme for 2007-2013. The current, ongoing programme is Horizon 2020[34], but there are many projects funded under FP7 which are still on-going[35].

1. **SCIENTIX (Belgium).**
   Project targeting population on primary and secondary STEM teachers, educators, researchers, policy-makers, industry, CSO, and other STEM professionals.
   Description: It supports a Europe-wide collaboration among STEM stakeholders. An online portal was built (2009-2012), to collect and present European STEM education projects. It organised teacher workshops and two European Conferences. From 2013 – 2015 Scientix expanded to the national level, setting up NCPs (National Contact Points) and involve STEM teachers as Scientix ambassadors in order to expand activities at the national level.
   Why is so important? The network of the Scientix ambassadors is operational to support teachers and schools implementing STEM. The National Contact Points (NCPs), aim to reach out to national teacher communities and contribute to the development of national strategies for wider uptake of inquiry-based and other innovative approaches to science and maths education.
   See in detail via: http://www.scientix.eu/web/guest .

[31] For more visit: https://ec.europa.eu/research/fp7/index_en.cfm?pg=understanding , 22.06.2016.
[32] SCIENCE EDUCATION for Responsible Citizenship, http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf , 15.06.2016.
[33] SCIENCE EDUCATION for Responsible Citizenship, http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf, 29.06.2016.
[34] For more visit: http://ec.europa.eu/programmes/horizon2020/ , 17.06.2016.
[35] For more visit: http://cordis.europa.eu/projects/result_en?q=programme/code=%27FP7%27%20AND%20contenttype=%27project%27 , 17.06.2016.

2. **FIBONACCI (France and partners).**
   Project targeting population on primary and secondary teachers, educators, CPD providers, other STEM stakeholders.
   Description: In large scale dissemination, institutions with high expertise in IBSME worked with other institutions to develop IBSME. It developed a wealth of pedagogical materials, CPD, peer learning visits, seminars and conferences.
   Why is so important? It produced a blueprint for a transfer methodology valid for a larger dissemination in Europe. The project lasted 38 months. 60 tertiary education institutions throughout Europe were involved, reaching some 7,000 teachers and over 300,000 students. Several countries developed IBSE CPD centres such as Italy with the SID centres etc.
   See in detail via: http://www.fibonacci-project.eu/.

3. **SiS-CATALYST (United Kingdom and partners).**
   Project targeting on children (age range: 7-14).
   Description: The focus is on the children least likely to progress to higher education. The objectives are: to learn and share knowledge about the different models of enabling children to aspire and progress to higher education, specifically by their engagement with science and secondly, to consider how this practice can have an impact on policies at institutional, national and European levels.
   Why is so important? The project has developed ethical guidelines, practical guides and self-evaluation tools to help institutions to assess their progress. It has set up a mentoring programme for newcomers and offered internships for students to engage in SiS activities. A website, workshops and case studies of successful interactions between children and higher education highlighted the potential of the SiS Catalyst approach.
   See in detail via: http://www.siscatalyst.eu/.

4. **YOSCIWEB - Young people and the images of science on websites[36].**
   Project targeting: education authorities, general public, industry, policy makers, secondary school students, teachers, university students
   Description: The main goal of **YOSCIWEB** was to analyse how web sites dedicated to the popularisation of science build and renew the social representation of science and scientists in the eyes of young people. The project aimed to offer guidance, innovation, reference and best practices to improve communication of science and to make science and scientific careers more attractive to young people.
   Why is so important? There has been a lack of tools and methodology to analyse the quality and the orientation of the websites and to adapt them to the various publics (students, pupils, disabled people, etc) and to the various images of science.
   As a result, YOSCIWEB has set up best-practice cases and recommendations for developers and managers of scientific websites on the most effective ways of promoting science to young people through the internet.
   See in detail via: http://www.yosciweb.eu.

[36] http://cordis.europa.eu/result/rcn/45883_en.html, 25.06.2016.

8.2 Examples of other selected STEM projects

1. **Amgen Teach**

   Launched in 2014, Amgen Teach is a European programme funded by the Amgen Foundation with direction and technical assistance provided by European Schoolnet (EUN). The programme is designed to deepen student interest and achievement in science by strengthening the ability of life science secondary school teachers to use inquiry based teaching strategies in the classroom. The launch of Amgen Teach follows a successful two-year pilot in four European countries (France, Germany, Ireland and Poland), which saw over 500 science educators improve their skills.
   The project is still in progress.
   See in detail via: http://www.amgenteach.eu.

2. **GLOBAL excursion**

   The aim of this project is to provide young citizens and their educators (teachers, parents, etc.) across Europe with a range of e-Infrastructures and access to expert knowledge on their usage for a joyful exploration of e-Science through e-Infrastructure.
   During its first year the project has been concentrating on developing and implementing a first version of the ViSH[37] in a truly participatory way. Teachers, as one of the main user groups, have been involved from the very beginning to co-design together with scientists and developers a service that meets their specific pedagogical requirements, that adapts to their personal teaching styles and that fits their specific teaching curricula.
   The project has been completed.
   See in detail via: http://www.globalexcursion-project.eu/index.html.

3. **Go-Lab: Global Online Science Labs for Inquiry Learning at School[38].**

   Go-Lab (2012-2016) creates an infrastructure (the Go-Lab Portal) to provide access to online laboratories run by research centres and universities worldwide. These online labs can be used by universities, schools, instructors, students and lifelong learners to extend regular learning activities with scientific experiments, giving students a real experience of research work.
   The project aims at: Creating pedagogical framework for inquiry learning with online labs; building the Go-Lab federation of online labs; providing one-click access to online labs and personalization facilities; building community of teachers, students and researchers to facilitate collaboration between schools and research institutions. To further support teachers in using online labs, Go-Lab offers workshops to introduce online virtual

[37] The ViSH is the main access point. It contains a selection of e-Infrastructures, a social network where scientists and teachers will be able to exchange and establish collaborations, and a virtual excursion room, where pupils will be able to experience real e-science applications in areas of high relevance for the future, such as Nano- and bio-technologies, volunteer computing, and life sciences.

[38] http://www.eun.org/about/projects/detail?p_p_id=webcontentbrowser_WAR_eunbaseportlet_INSTANCE_dB5P&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=1&_webcontentbrowser_WAR_eunbaseportlet_INSTANCE_dB5P_action=view-detail&_webcontentbrowser_WAR_eunbaseportlet_INSTANCE_dB5P_groupId=43887&_webcontentbrowser_WAR_eunbaseportlet_INSTANCE_dB5P_articleId=96449, 17.06.2016.

experimentations and remote laboratories as well as inquiry-based science teaching techniques.
The project is still in progress.
See in detail via: http://www.go-lab-project.eu/ .

8.3 Practices Promoting Responsible Science Education across Europe - example

1. **LUKA'S LAND OF DISCOVERY (Germany).**
   Project targeting population of the following age-range: 5-13 years.
   Description: This refers to a German education initiative in the field of photonics. In the frame of this initiative a series of experiment books was published as teaching material for schools to attract children to light and light-based technologies. These experiments were presented to school classes and children at several conferences, exhibitions and in museums within the past years.
   Why is so important? The initiative deals with experiments linking the field of photonics to the school curriculum. Many innovative technologies and applications are addressed and students experiment with them. As an outcome experiment books have been published in German.
   See in detail via: http://www.photonik-campus.de/.

8.4 Gender issues: Women in science – examples

1. **WOMEN IN TECH (WIT) (Finland).**
   Project targeting population on students in upper secondary and higher education – particularly girls, women and men in technology based professions.
   Description: Organised by women leaders in technology companies to encourage those interested in the future of business and technology. Activities aim to discuss how women can have a larger role in creating success stories in business and technology.
   Why is so important? Led by committed women leaders and involves variety of stakeholders from different sectors of society. Student unions organise activities and events for upper secondary schools girls together with companies.
   See in detail via: http://www.mytech.fi/women-in-tech.

2. **RAILSGIRLS (Finland).**
   Project targeting population on girls and women; especially girls and women at university and in upper secondary education.
   Description: Gives tools and creates a community for women to make technology more approachable. It is a global, non-profit volunteer community organising workshops for girls.

Why is so important? Workshops have demonstrated that the way learning and teaching takes place plays a major role in motivating students for STEM and in improving the learning outcomes in software programming (and STEM in general).
See in detail via: http://railsgirls.com/.

3. **Science: it's a girl thing! – Campaign launched by the European Commission[39].**
Campaign to encourage girls aged 13-18 to study science.
Description: That is the age range when young people tend to choose major school subjects that will influence their future career. This is the key point in their education where they either lean towards science or not. Campaign has being supported with active participation of women scientists acting as role models. More than 100 of women have contributed to the campaign through various activities: participation in workshops with teenagers and various events, video portraits, chats on the Facebook page to exchange with girls on their careers and passion for science, also photos of their professional and private life.
With Scientix support teachers are being addressed also.
See in detail via: http://science-girl-thing.eu/.

4. **Hypatia** – the continuation of campaign Science: it's a girl thing! Funded under H2020.
Objective: Hypatia will bring about lasting change in the way schools, science museums, research institutions and industry engage teenage girls in STEM across Europe. Bringing these stakeholders together with gender experts and teenagers themselves, Hypatia will develop, pilot and disseminate a unique modular toolkit of activities and guidelines for engaging teenagers in STEM in a gender-inclusive way. These innovative activities, based on existing European good practices, will be implemented in 14 EU countries and further afield, in schools, science museums and by institutions in research and industry, thanks to hubs of stakeholders strengthened through the project. The activities will have a central focus on gender-inclusive ways of communicating STEM, empowering teenage girls and exploring the range of skills that are needed for the great variety of STEM studies and careers open to young people. The Hypatia hubs will provide a sustainable basis for these activities to be carried out on the long term, with a focus on dissemination through networks and stakeholder engagement allowing the project impact to multiply.

9. Ethical aspects and Gender issues in STEM

The survey conducted by TNS Opinion & Social at the request of the EC, Directorate-General for Research & Innovation,[40] provides with the massive data and gives clear conclusions on various of fields in terms of science education and STEM. The report covers the 28 Member States. Some of the results in terms of ethics and gender studies have as follows:

[39] http://www.scientix.eu/web/guest/science-girl-thing, 25.06.2016.
[40] Responsible Research and Innovation (RRI), Science and Technology (2013), via: http://ec.europa.eu/public_opinion/archives/ebs/ebs_401_en.pdf, 15.06.2016.

- Respondents were asked whether they agreed or disagreed that respect for ethics and fundamental rights guarantees that scientific research and technological innovations will meet citizens' expectations. Seven out of ten (70%) agree, while only 7% disagree;
- More than eight in ten respondents agree that all researchers should receive mandatory ethics training (84%). In fact just over half (51%) totally agree. Just 3% disagree, while 9% are neutral;
- Just over eight in ten respondents (81%) agree that scientific experts should be obliged to openly declare possible conflicts of interest, such as their sources of funding, when they are advising public authorities. Almost half (49%) totally agree. Just 3% disagree, while 10% are neutral;
- More than eight out of ten (86%) respondents think it is important that scientific research takes equal account of the needs of men and women, with almost half thinking that this is very important (47%). Just under one in ten (9%) think this is not important;
- At least two thirds of respondents in across European countries think it is important that scientific research takes equal account of the needs of men and women;
- Respondents who are interested in developments in science and technology are more likely to mention improving the quality of research, making innovations better suited to men and women, and fostering more innovation in science and technology. For example 38% of those who are interested mention improving the quality of research, compared to 27% of those who are not interested. The same pattern applies when comparing those who are positive and negative about the influence of science on society.

10. Interviews with the EDU-ARCTIC Beneficiaries – the CAWI Survey

In order to fully prepare the analysis on STEM for the EDU-ARCTIC Program, the CAWI Survey (Computer Assisted Web Interview) has been issued among the consortium Beneficiaries. The main aim of the prepared questions was to better understand the barriers and missing gaps, in order to have the Program accurately tailored. Also surveyed Beneficiaries responded on general questions about STEM conditions in their countries. CAWI Survey was issued in Norway, France, Iceland, Poland and Faroe Islands. In open questions the original wording given by the consortium beneficiaries has been provided with linguistic changes only. The following questions were posed to the consortium beneficiaries:

1. Is STEM an essential component of compulsory education for young students in the age-range of 13 to 20 in your country? Possible answers: YES or NO.

Lp	Country	Answer
1	Norway	NO
2	France	YES
3	Poland	YES
4	Faroe Islands	YES
5	Iceland	YES

80% of Beneficiaries (4 of 5) reported that STEM is essential component of compulsory education for young students in the age-range of 13 to 20 in their country. (The program is dedicated to young students in the age-range of 13 to 20 and their teachers).

One Beneficiary – Norway, reported negatively.
In contrary Caroline Kearney[41] noted that Norway has a global approach to deal with STEM issues at national level; hence, STEM is an essential component of compulsory education in that country. Also Norway has additionally placed a real focus on attracting girls and women to science[42].

2. Are there any governmental (receiving national funding) projects in your country that support schools, teachers and students in the age-range of 13 to 20 in STEM education? Possible answers: YES or NO.

Lp	Country	Answer
1	Norway	NO
2	France	NO
3	Poland	YES
4	Faroe Islands	YES
5	Iceland	YES

60% of Beneficiaries (3 of 5) reported that there are governmental projects (receiving national funding) in their countries that support schools, teachers and students in the age-range of 13 to 20 in STEM education.

40 % of Beneficiaries (2 of 5) reported that there are no governmental projects in their countries. In fact, as given in previous point, Norway has a governmental project[43] and as stated by the Beneficiary there is "the LEGO-league" that is partly private initiative[44].

In order to move forward with the school improved education system governmental assistance is highly recommended and of essence.

---

[41] Kearney, C.: Efforts to Increase Students' Interests in Pursuing Science, Technology, Engineering and Mathematics Studies and Careers: National Measures Taken by 21 of European Schoolnet's Member Countries'. European Schoolnet, Brussels (2011), http://www.fisme.science.uu.nl/publicaties/literatuur/2011_european_schoolnet.pdf, 27.06.2016.
[42] Eurydice (2011): Science Education in Europe: National Policies, Practices and Research. Education, Audiovisual and Culture Executive Agency, Brussels, http://www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU(2015)542199_EN.pdf, 26.06.2016.
[43] National strategy: *Maths, Science and Technology for the Future (2010-2014)* is aimed at strengthening STEM competence from kindergarten all the way through to a person's working life. Norway's lifelong strategy is intended to increase synergies and cooperation between education and the world of work, so as to positively impact on recruitment to the STEM professions. The strategy's objectives spread across the priority issues shared in part by most European countries, including improving the quality of STEM teaching and teacher training, as well as encouraging gender balance and career choices in this area. For further details see: SCIENCE EDUCATION for Responsible Citizenship, http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf, 29.06.2016.
[44] Program that engages children in playful and meaningful learning while helping them discover the fun in science and technology. For further details see: http://firstlegoleague.org.

3. Is there a labor market demand for STEM careers in your country? Possible answers: YES or NO.

Lp	Country	Answer
1	Norway	YES
2	France	YES
3	Poland	YES
4	Faroe Islands	YES
5	Iceland	YES

All Beneficiaries (100%, 5 of 5) responded that there is a labor demand for STEM careers in their countries. As provided in the other part of this report there is a high demand for STEM careers across Europe.

4. What is the level of labor market demand for STEM in your country? Possible answers: Low, Medium, High.

Lp	Country	Answer
1	Norway	Low
2	France	High
3	Poland	High
4	Faroe Islands	Medium
5	Iceland	High

60% of Beneficiaries (3 of 5) reported that there is a high STEM labor market demand.
20% (1 of 5) reported that there is low and 20% (1 of 5) reported that there is Medium.

5. How would you describe the quality of teaching STEM in your country? (The original wording given by the consortium beneficiaries has been provided with linguistic changes only).

Lp	Country	Answer
1	Norway	There are various levels of the teachers, some being very creative and enthusiastic – consisting though the minority. One major issue though is the economy in the school system and the school management interest at municipality and county level.
2	France	High quality teaching in many French schools – STEM is compulsory in secondary education in France.
3	Poland	Due to curriculum teaching, STEM in all types of schools in Poland is obligatory. Mathematics is obligatory at all education stages, and the final exam after senior secondary school must be taken. Other STEM subjects are facultative in senior secondary schools. STEM education is also a priority of national of Education. The Minister every year sets out the basic orientations

		of the state educational policy in a given school year. One of the directions of the state educational policy in the school year 2014/2015 was to improve the quality of upper secondary education in relation to skills as set out in the program, with particular emphasis on skills in mathematics. In the school year 2015/2016 one of the priorities is Mathematical and Nature Education (science) under general education. Setting out priorities results in implementation of educational policy directions within tasks for the authorities of pedagogical supervision and teacher education institutions.
4	Faroe Islands	The quality level is medium to good. Structural problems do exist; for instance, to get good/experienced teachers in physics in secondary school. Overall, the issue has been identified and efforts are made to ameliorate the given area.
5	Iceland	It varies from poor to excellent and between schools and individual teachers. There is a national test in Iceland and includes following subjects: Mathematics, English and Icelandic (grade 4, 7 and 10). It gives the schools a chance to monitor and improve their performance. On the other hand it gives the government a good overview of national education developments. Cooperation between mid to higher education could still be improved but the actions that are being taken are evaluated well.

As stated by the consortium Beneficiaries, the quality of teaching STEM depends on various conditions and parameters. This was also reported in Chapter 7: Methods of encouraging careers in STEM of this *Desk Research*. There is a need to develop programs for teachers as they play key role in STEM approaches.

6. Are there any STEM collaborations between formal, non-formal and informal educational providers? (The original wording given by the consortium beneficiaries has been provided with linguistic changes only) .

Lp	Country	Answer
1	Norway	There are some various initiatives by all three types.
2	France	Very few activities proposed – further development is required.
3	Poland	Teaching STEM in Poland requires cooperation between schools and other educational providers. Many senior secondary schools cooperate with universities – especially universities of technology. There are also science centres funded by local governments, such as the Copernicus Science Centre (CNK) – a cultural institution, established and funded by the Capital City of Warsaw, Ministry of Science and Higher Education and the Ministry of Education. The centre specializes in interactive education, culture and science, including science, natural science and humanities. As well as

		universities, many science institutes have their educational mission and they cooperate with schools and disseminate science.
4	Faroe Islands	There is collaboration on various levels. There is science night, museum festival and various informal offers outside class room that I am involved in.
5	Iceland	There are some good examples between educational institutions and private companies. For example: two universities provide summer classes for young “scientists” with major support of private companies.

As stated by the Beneficiaries, there are examples of collaboration between formal, non-formal and informal educational providers. Be that as it may, there is also a need for furthering collaborations of this kind, since this will have a substantial impact on many various aspects in future and STEM approaches.

7. Do you see that greater attention should be given to promoting STEM in your country? Possible answers: YES or NO.

Lp	Country	Answer
1	Norway	YES
2	France	YES
3	Poland	YES
4	Faroe Islands	YES
5	Iceland	YES

All Beneficiaries (100%, 5 of 5) responded that greater attention should be given to promoting STEM in their countries. Norway underlines that such attention should be practical and be carried, in particular, towards new technologies.

8. Is there gender parity among students who have chosen to study STEM in your country?

Lp	Country	Answer
1	Norway	There is gender parity in some fields. There are more girls than boys in some areas, especially in higher education [university level] (ratio 70:30).
2	France	More men choose this field of study.
3	Poland	More men choose this field of study.
4	Faroe Islands	There is gender parity.

5	Iceland	More men choose this field of study. There are more girls in some areas and we can observe a growing tendency.

60% of Beneficiaries (3 of 5) reported that more men choose to study STEM in their countries.
Such statistics were also observed across European countries.
Interesting information is being provided by Norway and the Faroe Islands, where we can observe gender parity. In light of the observations in terms of gender parity across Europe, this information is satisfactory. In Iceland we can observe a growing tendency where women are being more attracted to study STEM than men.

9. Do you see that greater support and promotion of actions should be given to attract women to STEM in your country? Possible answers: YES or NO.

Lp	Country	Answer
1	Norway	NO – it should be gender equal
2	France	YES
3	Poland	YES
4	Faroe Islands	YES
5	Iceland	NO – it is not an issue in Iceland

60% of Beneficiaries (3 of 5) reported that greater support and promotion actions should be given to attract women to STEM in their countries.
40% (2 of 5) reported negatively. Norwegian beneficiary stated that there should be gender parity, whereas Icelandic beneficiary claims that this is not an issue in their country. It is assumed that question has not been properly understood. As stated in other part of this report employment in STEM is male-dominated, hence greater support and promotion actions should be undertaken to attract women to pursue careers in STEM. In Iceland we can observe a growing tendency where women are being more attracted to study STEM than men and it may be that support and promotion of action brings the expected result.

10. Are schools in your country, adequately equipped with ICT tools (Internet access, computers, projector, speakers, webcam, etc.) in order to participate in the *EDU-ARCTIC program*? Possible answers: YES or NO.

Lp	Country	Answer
1	Norway	NO
2	France	YES
3	Poland	YES
4	Faroe Islands	YES
5	Iceland	YES

80% of Beneficiaries (4 of 5) reported that schools are adequately equipped with ICT tools (Internet access, computers, projector, speakers, webcam, etc.) in their countries.
20% (1 of 5) reported negatively.

11. What percentage of schools is adequately equipped with ICT tools (Internet access, computers, projector, speakers, webcam, etc.) in your country? Possible answers: Less than 40%, Between 40%-60%, Above 60%.

Lp	Country	Answer
1	Norway	Less than 40%
2	France	Above 60%
3	Poland	Above 60%
4	Faroe Islands	Above 60%
5	Iceland	Above 60%

80% of Beneficiaries (4 of 5) reported that more than 60% of schools in their countries are adequately equipped with ICT tools (Internet access, computers, projector, speakers, webcam, etc.) and 20% (1 of 5) reported that it is less than 40%.

That information allows assuming that schools in Beneficiaries countries are ready enough to participate in the *EDU-ARCTIC program*. This equally implies that ICT may be widely used in STEM educational approach.

12. Do you think that polar studies are important in STEM in your country? Possible answers: YES or NO.

Lp	Country	Answer
1	Norway	NO
2	France	NO
3	Poland	NO
4	Faroe Islands	YES
5	Iceland	YES

60% of Beneficiaries (3 of 5) reported that polar studies are not important in STEM in their countries. The key question was whether there is any interest and teacher's commitment towards polar studies. Norway also stated that "today there is about 10 hours of education in all subjects in primary school (10-16 years old pupils) and about 15 hours at the gymnasium (16-18 years old) level". There is not enough time to address all science's subjects.

Faroe Islands and Iceland responded YES (40% of Beneficiaries) and such statement is very satisfactory in that matter.

13. What subjects consist of part of STEM for young students in the age of 13 to 20 in your country?

Lp	Country	Answer
1	Norway	Biology, Chemistry, Mathematics, Physics, Computer science
2	France	Biology, Chemistry, Mathematics, Physics, Computer science, Geography
3	Poland	- **junior secondary school:** Geography, Biology, Chemistry, Physics, Mathematics, Computer skills,

		Technical subject; - **senior secondary school:** Geography, Biology, Chemistry, Physics, Mathematics, Science (subject for those students, who do not choose STEM subjects for specialization), Computer skills
4	Faroe Islands	Science, Technology, Geography, Engineering, Mathematics, Physics, Chemistry
5	Iceland	Science, Geography, Mathematics, Physics, Chemistry **- elementary school:** emphasis is on Mathematics with basic education in Physics and Chemistry; - **high school or university**: pupils can select subjects of their interest and they receive an extensive education. For example: if student selects natural science and extensive education is being given in Mathematics, Calculus, Chemistry, Astronomy, Physics and Biology

It is strongly assumed that subjects are the same in the Beneficiaries countries. Also if pupils (students) select subjects of their interest, they receive an extensive education in that area.

14. What is the average number of hours per week allocated to STEM in your country?

Lp	Country	Answer
1	Norway	The number of hours depends on school type and specialization. It can be from 1 to 10 on average. There are no proper statistics on that.
2	France	8 to 10 on average, up to 15 depending on specialization.
3	Poland	- junior secondary school: 11; - senior secondary school: First year of education in higher secondary school – 9 hrs. per week. Second and third – it depends on students' choice. Compulsory mathematics – 3 hrs. They can choice STEM extension program. Mathematics – add 3 hrs. Other subject – 4,5 hrs. a week.
4	Faroe Islands	- Age 7 – 12: 5 – 6 hours a week; - Age 13 – 15: 8 – 10 hours a week. Some have more because they choose to; - Age 16 – 20: varies a lot. An average seems to be 6 to 12 hours a week.
5	Iceland	The number of hours depends on school type and age of students. Number of hours per week allocated to STEM can be even 40% of total school hours.

Answers depend on the level of education and types of school. It is assumed that average number of hours per week allocated to STEM is:

- Primary school (7-12) – 8 hours
- Secondary school – Gymnasium (13-16) – 8 hours
- Higher secondary school (16-19) – 8 hours
- Collage/university – depends on specialization: up to 15 hours.

11. Conclusions

The need to improve the quality and adequacy of the science education and STEM among young European people, who leave schools, has been recognized both at EU and national level. Some of the countries still should seek improvements in that field. The current situation, which Europe is struggling with, high unemployment among young people; this underlines the urgent need to address the importance of STEM at all levels: global, European and national level.

The most important issues are:

- Promoting a positive image of science education and STEM based on facts;
- Raising the general level of public awareness about the seriousness and significance of science education and STEM;
- Improving science teaching and learning;
- Improving continuous increase in students' interest in the field of science and STEM;
- Seeking for a long-term STEM projects and programs in order to receive the proper effects;
- Developing programs for teachers as they play key roles in STEM approaches;
- Raising parents awareness about importance of science education;
- Providing high quality career advice in schools;
- Promoting STEM careers among young girls;
- Seeking better gender balance. Not only promoting STEM careers among young girls, but also keeping that balance stable so that young boys shall remain interested to pursue careers in STEM. Higher promotion among young girls may turn in reduction of interest among young boys due to lack of proper promotions;
- Promoting public awareness among young people that better education leads to new science's discovery;
- Promoting the need at EU and national level for more frequent STEM programs evaluations;
- Promoting the need for innovative tools and effective methods of teaching science on a regular base in schools;
- Establishing strong links between the worlds of research and young members of the society (youngsters) in order to increase their ability to understand scientific messages and scientific language;
- Increasing the awareness of the importance of the Arctic among the general public.