Stimulating interest in STEM careers among students in Europe: Supporting career choice and giving a more realistic view of STEM at work

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Abstract: In most countries in Europe, interest and achievement in science, technology, engineering and mathematics (STEM) topics is declining. This in turn, leads to low levels of entry to STEM tertiary studies and STEM careers – posing a major challenge for the future competitiveness of European countries on the world stage. By 2020, more than 800 000 technology posts will be unfilled due to the skills gap, and even lower level positions will require increasing levels of STEM knowledge and competence.

Hence, it is critical to address this issue. Numerous efforts have been made across Europe to better engage pupils on several levels, including: increasing students interest in STEM by enlivening STEM lessons at school with new and improved pedagogical approaches, giving students a better understanding of the relevance of STEM to life through informal and formal education, linking the world of work in STEM and the classroom, engaging students in awareness-raising activities around STEM jobs, and organising STEM fairs.

All of these measures have presented some degree of success, but need to be taken up more widely. We will review key examples in Europe, and examine barriers and facilitators to wider uptake of approaches to support students in choosing STEM.

Keywords: Science, technology, engineering, mathematics, careers, jobs, Europe, pedagogy, awareness-raising

Introduction

Over the last 10 years, concern has been increasing about the mismatch between demand and supply for qualified science, technology, engineering and maths (STEM) professionals in Europe. Increasingly technically-dependent business process, and research and innovation driven economies, have a consequent impact on the need for personnel with high levels of skill in these areas. Meanwhile, demographic change, combined with lower interest in STEM studies and careers, is resulting in a decrease in percentage of STEM graduates – although the total number has risen somewhat due to increased access to tertiary education. The potential negative economic impact of undersupply is of concern particularly at policy level, due to opportunity costs and loss of competitiveness compared to other regions of the world – particularly South Asia – where a huge number and proportion STEM graduates are the norm.

In addition, the type and quality of STEM graduates in Europe are a concern, with particularly significant lacks of computer science, physics and engineering graduates. Other research indicates that in the future there will be less qualified workers than jobs available in the future, (Crecim, 2013, Berkhout et al. 2012) and that even lower level jobs will require a higher basic level of STEM competences.

This paper will review the situation in terms of skills gap in Europe, from a general STEM perspective but also with a review of existing data on specific sub-areas of STEM skills. We will summarise results from European STEM education research and awareness-raising projects taking place over the last five years, which each cover between three and thirty countries. We will focus exclusively on initiatives that are based on school-industry partnerships. We will categorise projects according to a typology developed in previous STEM education research. Recommendations will be given for future areas of research which remain to be explored.

Why is it so important to stimulate interest in STEM studies and careers? The skills gap in Europe.

"Recruitment to the STEM (Science, Technology, Engineering and Mathematics) sector and proportionate decline in the number of STEM graduates has been an increasing concern in the EU. Multiple research studies register a growing disengagement of young people with STEM subjects in school and a decreasing interest in STEM careers. The decline is particularly noticeable in secondary school and is exacerbated by the parallel development of stark gender differences," say Kudenko and Gras (in press).

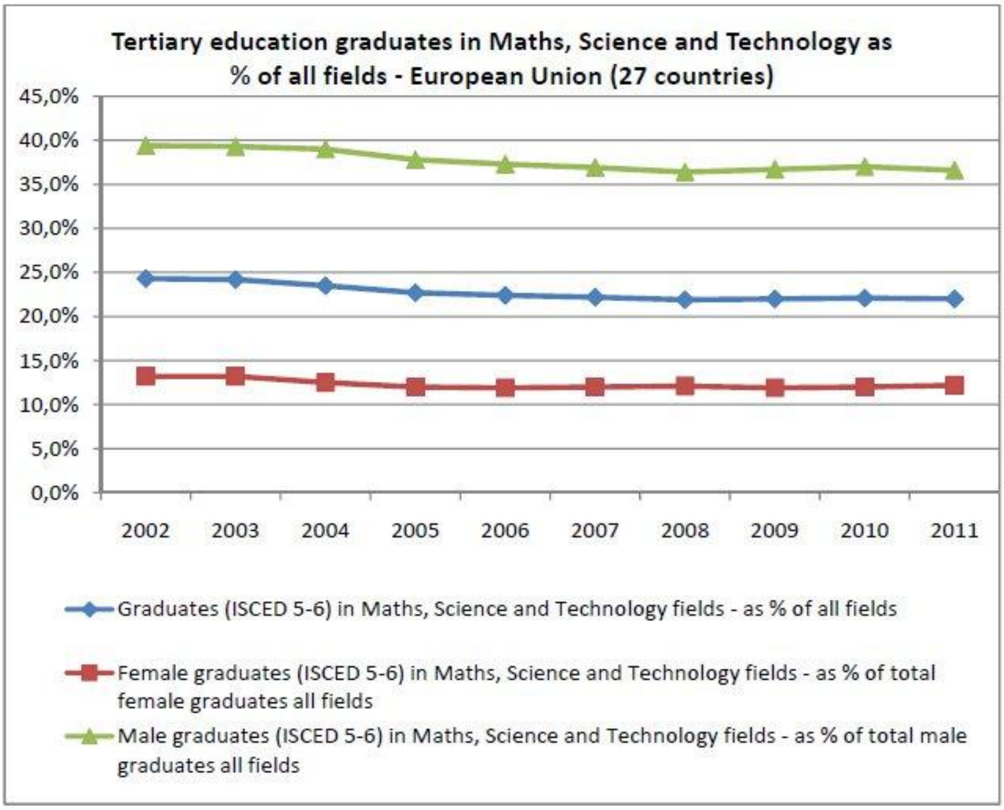

Figure 1: Tertiary education graduates in Maths, Science and Technology as % of all fields – EU 27, Source: Eurostat

The number of science enrolments and graduates in Europe has been slowing down over the last decade, declining from 24.3% in 2002 to 22.6% in 2011 according to Eurostat, and males still predominate the field representing more than 80% of graduates in particular in the fields of computing and engineering.[1] We now go on to examine the particular gap in these two fields.

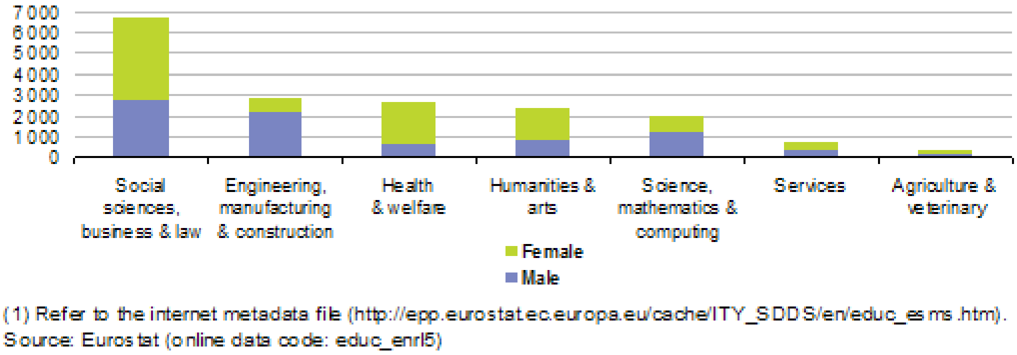

Figure 2: Students in tertiary education, by field of education and by sex, EU-27, 2010 Source: Eurostat

<u>Engineering</u>

"An actual or impending shortage of engineers was the cause of much concern in the boom years before the financial crisis. The phenomenon is widespread (EU 2008), especially in industrialised countries" says Becker (2010). The willingness among European young people to study engineering is in general low, as indicated in the figure below.

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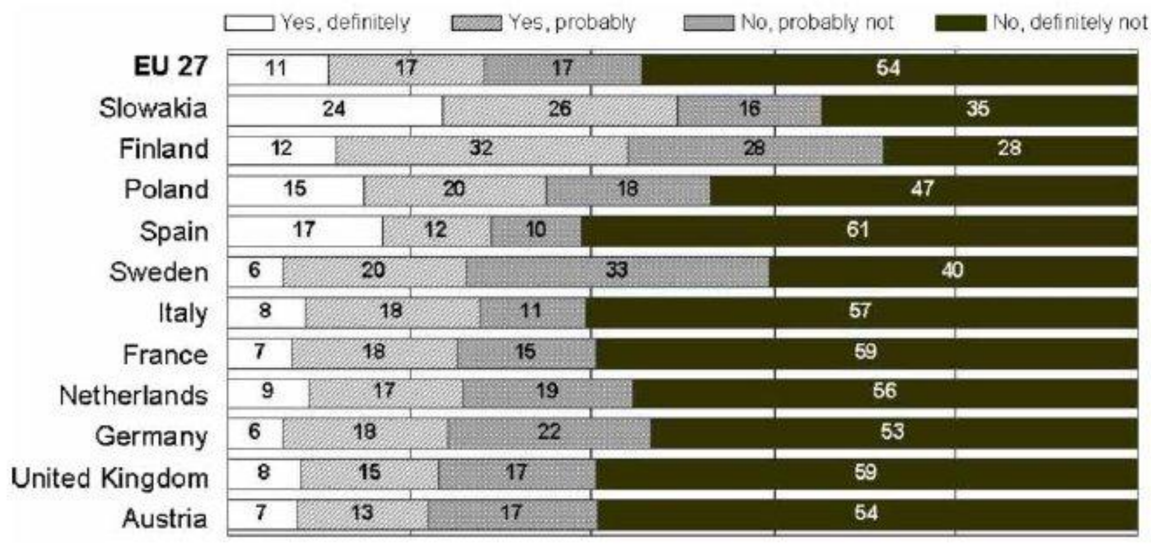
[1] The STEM gender imbalance was not reduced during the decade 2000-2009. Less than one third of STEM graduates were women in 2000 and this was still the case in 2009. Moreover, the country deviation is relatively small. This means there have not been any real success stories in improving the STEM graduate rate of women across Europe.



Willingness of young people to study engineering in selected European countries (EU 2008).

Figure 3: Willingness of young people to study engineering in selected European countries. Source: Eurostat

According to the EU Skills Panorama (2012), recruitment difficulties for qualified engineers already exist today, and demand is likely to increase due to the growing need for “green” engineers in consequence of new energy efficiency and environmental building regulations. Shortages are already evident in Austria, Flemish Belgium, Czech Republic, Germany, Hungary, Italy and the UK – the opportunity cost of this shortage is estimated at € 6.6 billion for Germany alone.

<u>Computer science and ICT</u>

Another particularly notable skills gap is evident in the field of ICT, as noted in numerous European Commission policy documents and funded research papers. There is “an important need to address ICT-related skills (e-skills) issues in order to respond to the growing demand for highly-skilled ICT practitioners and users, meet the fast-changing requirements of industry, and ensure that every citizen is digitally literate in a lifelong learning context requiring the mobilisation of all stakeholders” according to the Communication on “e-Skills for the 21st Century” in 2007. Since then, numerous further publications and experts have highlighted the need to continue awareness-raising on the issue of e-Skills. For instance, computer science graduate numbers on an annual basis are in decline in Europe according to Eurostat (see figure 4), and there are currently a large number of hard to fill vacancies in ICT in large and small countries (figure 5).

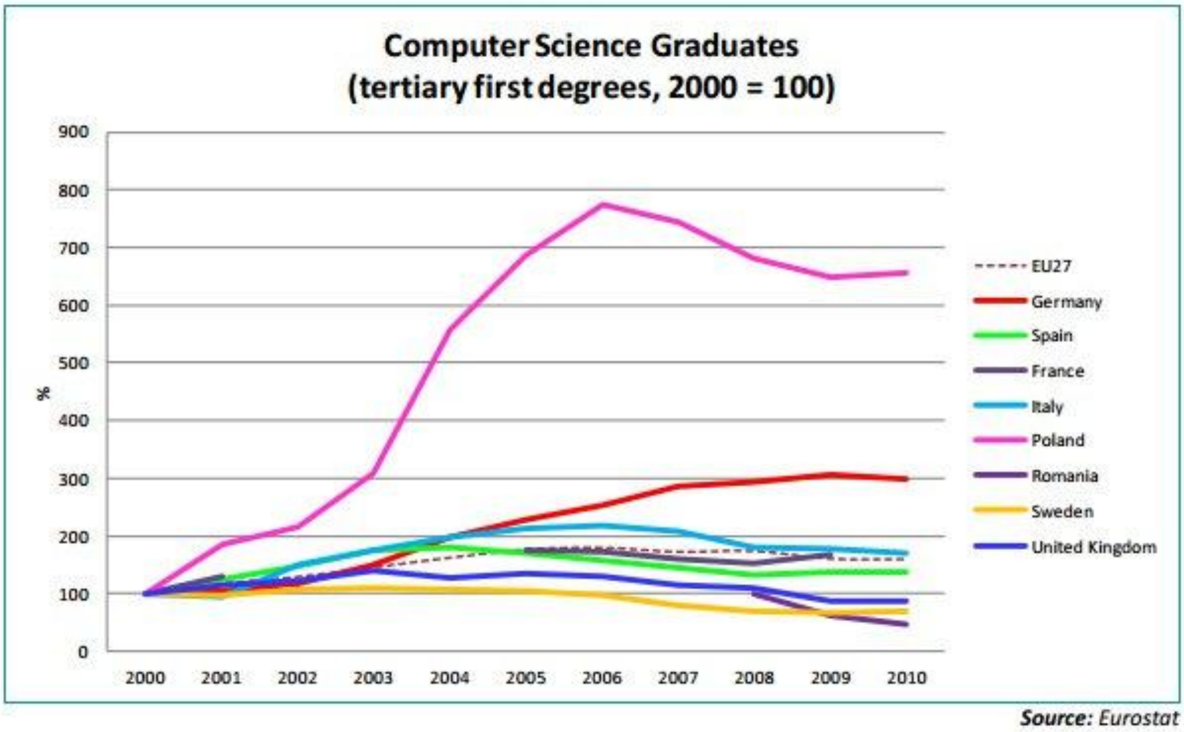


Figure 4: Computer science graduates in Europe 2000-2010, Source: Eurostat

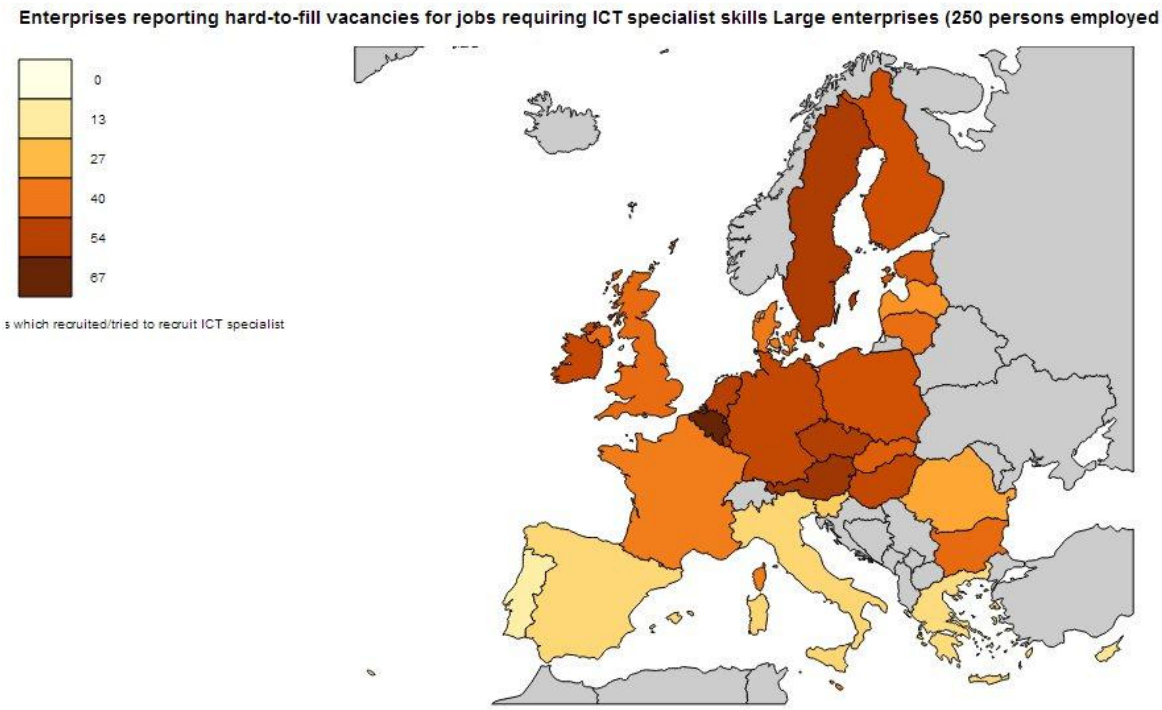


Figure 5: Enterprises reporting hard to fill vacancies for jobs requiring ICT specialist skills. Source: Eurostat[2]

As regards positions which today are seen as unskilled, by 2020 they will require better e-Skills than similar positions today - 90% of jobs in the near future will require ICT skills of some level. Indeed,

[2] Eurostat - Community survey on ICT usage and eCommerce in Enterprises

workers in jobs today already feel they are insufficiently skilled according to the Eurostat Community survey on ICT usage in Households and by Individuals. Meanwhile, ICT practitioners and professionals continue to progress along a 'leaky pipeline' with some groups dropping out of the profession despite taking tertiary studies in the field (IDC 2009) – particularly women, who already participate at a very low level in computer science.

All of the above-mentioned factors could lead to Europe not being able to fill as many as 700,000 IT jobs by 2015 (Empirica, 2013).

Initiatives to reverse the trend: types, results and findings

International, national and regional initiatives have been launched across Europe to try to increase students' interest in STEM studies and careers. They include measures aimed at increasing students interest in STEM by enlivening STEM lessons at school with new and improved pedagogical approaches, giving students a better understanding of the relevance of STEM to life through informal and formal education, linking the world of work in STEM and the classroom, engaging students in awareness-raising activities around STEM jobs, and organising STEM fairs. As the number of initiatives is extremely large – and too large to cover adequately in this paper, we will focus exclusively on initiatives based on school-industry partnerships. The figure below schematises the types of cooperation and actors involved in such partnerships.

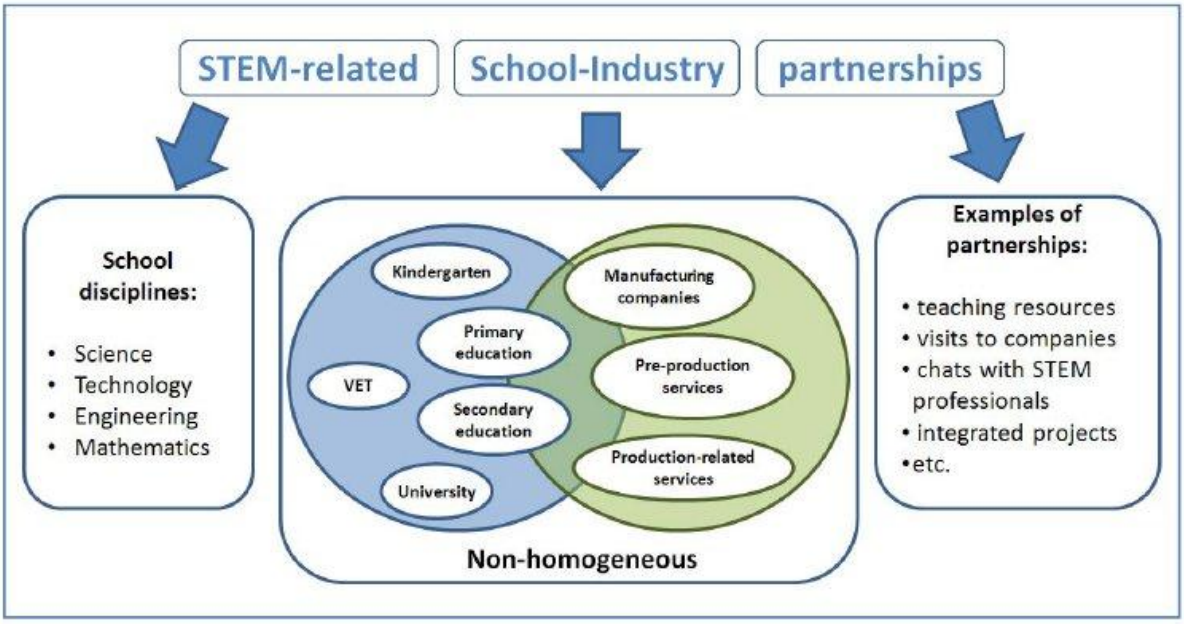


Figure 6: Schematic of school-industry partnerships. Source: Crecim, UAB

Iredale (1996) underlines the benefits that such partnerships can bring to students: "The vision of the future for many educationalists, industrialists and politicians is a partnership between education and industry that will promote a wide range of experiences that will equip young people with the 'opportunities, responsibilities and experiences of adult life' [...] Those who support the industry/education movement believe that closer links between education and industry bring general benefits to both parties. It is suggested that students and teachers profit through gaining an insight into the world of work, learning through first-hand experience about the needs of industry and how it works."

We will review key examples in Europe, and examine barriers and facilitators to wider uptake of approaches to support students in choosing STEM. First, we explain the framework for categorising initiatives and then we go on to examine the initiatives and their results in more detail.

Through the inGenious platform, a pan-European partnership between major industry players, national Ministries of Education and other key education stakeholders, a typology of initiatives to promote interest in STEM studies and careers was developed. This framework, developed by CRECIM at the Autonomous University of Barcelona, categorises initiatives and projects according to the following factors:

A. Students' engagement in the study of STEM in school: this factor relates to innovative approaches such as inquiry-based learning and contextualisation of STEM topics in classroom activities, which aim to make STEM learning a more engaging process.
B. Career information: this factor relates to initiatives that address the issue that many students have an unrealistic perception of scientific and technical careers, and hence give students more access to "real life" job information and role models in STEM.
C. Personal characteristics: role playing, self–efficacy allowing students to understand that how their own personal characteristics might help them in STEM studies or jobs.
D. Social perception of the industry work related to STEM – helping students to better understand social and ethical aspects of the STEM industry.

In terms of working modalities, CRECIM also identified four common types of initiative:

1. Providing resources for schools to promote the improvement of scientific or technological knowledge potentially related to the company (materials, ambassadors, courses, etc.)
2. Establishing direct communication between STEM professionals and students.
3. Giving accessibility of the company premises to schools/to students.
4. Engaging STEM professionals with students' work.

The below table indicates a number of key examples from each of these levels. These examples are chosen to be illustrative of successful (in terms of stakeholder engagement, recognition of impact by stakeholders, and student impact) approaches at each of the levels identified.

Level of initiative	**Short description**	**Factor(s)**	**Modality/ies**
International (European)	e-Skills week campaigns – in 2012 and 2014, large scale awareness raising to promote ICT studies and careers through Ministries of Education, IT industry partners, associations	B, C, D	1, 2, 3
International (global)	Intel International Science and Engineering Fair – worldwide competition building on national science fairs rewarding excellent student-led research projects	A, C	1, 2
National	Jet-Net – large scale platform of industry and education partners, linked to other areas of government, providing direct school-business links, teaching and learning materials/activities and careers events	A, B, C, D	1, 2, 3, 4

National	STEMNET – a UK platform for schools to find STEM ambassadors to visit schools, support in STEM teaching and setting up of science clubs	A, B, D	1, 2, 4
Regional	The Mallow Festival of Science, Mallow Region, Ireland – an event engaging university departments, business, schools, and science centres to organise formal and informal learning events on STEM for students, including talks, science fair, and fun science experiments.	A, B, D	2, 4
Regional	Girls, dare to do science! (*Les filles, osez les sciences !)* in the Mayene Region of France engages companies with schools to send role models into schools, to arrange visits to companies and organise a one-day conference on specific STEM career areas, plus a travelling exhibition, organised by the Femmes et Sciences 53 association.	B, C, D	2, 3, 4

The table below summarises key findings in common across these initiatives for factors A-D as regards teacher and student impact.

Factor	**Teachers**	**Students**
A	More confidence in using innovative teaching methods such as inquiry-based and problem based learning. Higher awareness of resources available to support them (human and otherwise). Easier access to training opportunities in STEM pedagogies and content.	Increased enjoyment of STEM lessons and reported interest in STEM both in and out of school. Increased knowledge and understanding of specific topics tackled. More collaborative experience and interaction in STEM classroom activities. Reported more interest in pursuing STEM at higher levels. Increased practical skills.
B	More up to date knowledge of career opportunities for students helps teachers relate STEM content in teaching to real-life examples.	Increased awareness of careers that involve STEM – i.e. not just research but also industry. More realistic perception of what a “scientist” or “technologist” does and less stereotypical expectation of the type of person to do such a job.
C	Teachers themselves are more enthusiastic about teaching STEM topics (particularly at primary level, where they may typically have less confidence in STEM topics).	More interest in taking up STEM studies and careers. Clearer understanding of the relationship between their own characteristics and that of a person working in STEM (e.g. creativity, team working).
D	Better understanding of how to tackle social and ethical issues in the classroom.	Better understanding of social, ethical and legal constraints and measures taken by industry/research to tackle societal and ethical challenges. Increased interest among girls in STEM as they are typically more concerned by such issues.

All of these measures have presented some degree of success in terms of achieving impact via short term indicators (e.g. immediate expressions of attitudinal change to be more positive about STEM topics by students), but need to be taken up more widely and implemented over a longer time period to have a clear impact on longer term indicators such as entry to tertiary studies in STEM which remain negative.

Given the wide range of potential benefits for teachers and students, it is important to highlight that both industry and educators do not always find it easy to implement school-industry partnerships. Indeed, school-industry partnership remains far from the “norm” in most European schools, and is still challenging from a legal perspective in some countries where business involvement has been traditionally discouraged. The points in the table below have been reported by participants and project leaders in inGenious as obstacles to further uptake and wider extension of school-industry partnerships for STEM, and are categorised using CRECIM’s preliminary findings. For each obstacle, potential facilitators are proposed.

Obstacle type	**Detailed obstacles**	**Potential facilitators**
Structural	• Lack of resources (economic, human, time) Lack of support from internal management and external partners • Geographical distance between school and industry	• Ministries of Education should include recommendations in STEM curricula/teaching requirements for school-industry partnerships • More virtual partnerships forms should be developed to reach schools in distant locations
Motivational	• Mismatch of goals/objectives between schools and industry • Lack of interested individuals • Lack of continuity/commitment	• Clear partnership agreements should be drawn up based on best practice models to clarify objectives and targets • Individuals (in companies and schools) need information and training to understand the benefits of partnerships • Companies should make long term commitments to partner with dedicated staff
Procedural	• Communication between partners can fail • Regulations e.g. students not allowed in laboratory facilities	• Intermediaries (broker organisations such as associations) should support partnerships to help resolve communication difficulties • For difficult/dangerous facilities to visit, companies can create virtual or remote tours
Cultural	• Different realities of industry and education • Clashing schedules • Negative stereotypes of industry	• Intermediaries (broker organisations) should support partnerships to help resolve communication difficulties • Time needs to be made available by companies (e.g. through volunteer programs) and schools (e.g. by identifying “project days”) to ensure availability • Peer learning between teachers should ensure they are positive about the

		potential of the partnership

Conclusions

The challenge of increasing the number and quality of STEM graduates in Europe is not trivial, particularly in the areas of engineering and computer science where the problem is most acute. Bridging the gender gap could contribute to addressing the problem, but a more large-scale approach to engage all pupils in STEM in a more comprehensive way is needed.

School-industry partnerships, giving young people access to role models, new learning experiences, industry facilities and more have the potential to improve the situation. The four factors and modalities identified have can improve outcomes for both teachers and students in STEM teaching and learning - the cases outlined have delivered positive results by improving the STEM learning experience, while also giving a more authentic context for STEM knowledge by giving students "real life" understanding of STEM jobs and professionals, as well as related social and ethical aspects.

However numerous obstacles remain – whether structural, motivational, procedural or cultural – for both education and industry players. Measures could be taken by policy makers, intermediary associations, companies and schools themselves to make it easier to organise such partnerships at both a strategic and implementation level. Up to now, research has focused on assessing which of such facilitators might have the highest impact in enabling school-industry partnerships. Equally, few studies have been able to identify if specific school industry partnerships have had an impact on the long term uptake of STEM studies and careers. More research is needed on such partnerships, but they offer a promising avenue for enhancing the quality and quantity of STEM graduates in Europe.

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