European Coordinating Body for Maths, Science and Technology (ECB)

DELIVERABLE SUBMISSION SHEET

To: Maria KARAMITROU

EUROPEAN COMMISSION
Directorate-General for Research & Innovation
RTD/B/6
B-1049 Brussels Belgium

From: EUN Partnership AISBL

Project acronym: ECB   Project number: 266622

Project manager: Rinske van Den Berg - Technical

Project manager: Agueda Gras-Velazquez - Scientific

Project coordinator: Marc Durando

The following deliverable:

Deliverable title: Country reports on research developments

Deliverable number: 2.5

Deliverable date: 30/04/2014

Partners responsible: Universitat Autònoma de Barcelona

Status: X Public ☐ Restricted ☐ Confidential

is now complete. ☑ It is available for your inspection.
☐ Relevant descriptive documents are attached.

The deliverable is:

☑ a document
☐ a Website (URL: ....)
☐ software (...........................)
☐ an event
☐ other (...........................)

Sent to Project Officer: Maria KARAMITROU	Sent to functional mail box: Maria.KARAMITROU@ec.europa.eu	On date: 20/05/2014

Published in May 2014. The views expressed in this publication are those of the authors and not necessarily those of EUN Partnership AISBL.

http://www.ingenious-science.eu

Coordinated by European Schoolnet

The work presented in this document is partially supported by the European Commission’s FP7 programme – project ECB – European Coordination Body (Grant agreement Nº 266622). The content of this document is the sole responsibility of the consortium members and it does not represent the opinion of the European Commission and the Commission is not responsible for any use that might be made of information contained herein.

ECB - WP 2

D 2.5 - COUNTRY REPORTS ON RESEARCH DEVELOPMENTS

CONTRACT NO	266622
DATE	30/04/2014
ABSTRACT	A review of national research on school-industry collaboration in the area of STEM education.
AUTHOR, COMPANY	CRECIM-UAB
REVIEWER, COMPANY	Arjen Schat, Philips Signe Rosin, Tigerleap Foundation Tobias Eriksson, Teknikfortetagens Service I Sverigie AB
WORKPACKAGE	WP 2
CONFIDENTIALITY LEVEL[1]	Public
FILING CODE	ECB- Country reports on research developments.Doc
RELATED ITEMS	

1 1 PU = Public

PP = Restricted to other programme participants (including the EC services);

RE = Restricted to a group specified by the Consortium (including the EC services);

CO = Confidential, only for members of the Consortium (including the EC services).

INN - Internal only, only the members of the consortium (excluding the EC services)

EXECUTIVE SUMMARY

During the last decade, the need to promote Science, Technology, Engineering and Mathematics (STEM) education in order to improve students' literacy and aspirations towards careers in these fields has been an important concern in most western countries. Several research studies and reports published at international level have been identified and referenced throughout different documents and research papers produced so far within the inGenious project, constituting a well established state-of-the-art in the field of STEM education relevant to School-Industry (S-I) partnerships. However, existing research studies in Europe which have been published only at national and local level are much more difficult to identify, especially if research results have been disseminated only nationally in national languages.

The present document offers a review of national and local research developments in this area in the countries involved in the inGenious project, in order to complete the state-of-the-art in the field of STEM-related partnerships previously established. To do so, STEM national experts from across Europe have been consulted in order to identify (i) relevant research in the field of STEM related to S-I initiatives which had achieved impact to be published at national and international level, and (ii) research results about existing national and local initiatives in Europe that have been reached only at national level with research results disseminated only in the national language at national level. An effort has been done to present main results or conclusions about the reported references, although in some cases the abstracts did not provide enough information to do so, since they were more focused on methodological details or on the general goals of the reported studies or projects. In these latter cases, those studies that have been considered interesting due to the topic that they address or the approach that they propose have also been mentioned despite their results or conclusions have not been reviewed.

The review of country reports on STEM-related school-industry partnerships has allowed to confirm many of the ideas that had already been identified along the whole study performed within WP2. However, some certain areas were found as especially relevant in different countries, confirming the need to promote cross-country cooperating across Europe in order to take advantage of the strengths and potentialities of each country in the field of promoting STEM careers by means of S-I cooperation.

TABLE OF CONTENTS

INTRODUCTION

The need to promote Science, Technology, Engineering and Mathematics (STEM) education in order to improve students' literacy and aspirations towards careers in these fields has been an important concern in most western countries during the last decade. Several research studies and reports which were published at international level have been identified and referenced throughout different documents and research papers produced so far within the inGenious project, constituting a well established state-of-the-art in the field of STEM education relevant to school-industry partnerships (i.e. Archer, 2013; Berkhout *et. al.*, 2012; HBrandford, Brown, and Cocking, 2000ardisty and Cunningham, 2013; ERT, 2009; OPM, 2004; Savickas *et. al.*, 2009;; among many others). However, existing research studies in Europe which have been published only at national and local level are much more difficult to identify, especially if research results have been disseminated only nationally in national languages.

With this in mind, and in order to complete the state-of-the-art in the field of STEM-related School-Industry (S-I from now on) partnerships previously established (see previous deliverable), **the aim of the present document is to review national/local research developments in this area in the countries involved in the inGenious project**. To do so, a methodology for gathering these "national/local" research results, by on-line surveying STEM national experts designated by inGenious partners in each country, was established.

Data collection methodology

In order to review research developments in the field of STEM-related S-I partnerships disseminated at national/local level, a call for national experts in this area was launched (see Annex I) within the following partner countries in the inGenious project:

- Austria
- Belgium
- Denmark
- Estonia
- Finland
- France
- Germany
- Israel
- Italy
- Netherlands
- Portugal
- Slovakia
- Spain
- Sweden
- United Kingdom

Through this call, the aim was to identify national academic experts with relevant experience and knowledge on S-I collaboration in STEM education who would compile high quality information on the subject matter within their countries. From the suggested STEM national experts provided by the inGenious partners[2], a selection was made based on their academic curricula and professional experience. The selected experts (see Table 1) were tasked to identify (i) relevant research in the field of STEM related to S-I initiatives which had achieved impact to be published at national and international level, and (ii) research results about existing national and local initiatives in Europe

[2] It should be pointed out that, despite the attempts to have STEM experts from all the partner countries, no proposals were received from Finland, Italy and Denmark, and thus no information regarding these countries has been collected for the present document.

that have been reached only at national level with research results disseminated only in the national language at national level. In order to facilitate the provision of information by the national experts, a questionnaire was made available for them (the requested fields are shown in Annex II). Assuming that many of the original publications would be written in the corresponding national languages, the experts were required to summarise their findings in English and to provide an abstract with the main results or conclusions of the identified studies and/or reports. In those cases in which the summary was not complete enough and the referred studies or reports were available and written in English, the original sources were also consulted. However, sometimes the reported information provided by the experts did not show enough relevance to STEM-related S-I partnership (for instance, some reported studies were mainly focused on entrepreneurship but with no link to STEM), and in those cases the references provided were omitted[3]. An effort has been done to present main results or conclusions about the reported references, although in some cases the abstracts did not provide enough information to do so, since they were more focused on methodological details or on the general goals of the reported studies or projects. In these latter cases, those studies that have been considered interesting due to the topic that they address or the approach that they propose have also been mentioned despite their results or conclusions have not been reviewed.

Table 1: List of countries from which documentation on STEM-related S-I partnership was included in this review[4].

Austria	Estonia	Israel	Slovakia	Sweden	France
Belgium[5]	Germany	Netherlands	Spain	United Kingdom	-

In certain cases, we found it relevant to include other national or international studies not provided by the experts in order to complement and better frame the context. However and as previously mentioned, the main content of the report is based on the information collected by the national experts, which will be used to complete and update the bibliographic research performed along the project and synthesised in the final deliverable of the WP2.

Structure of the report

---

[3] In the particular case of Portugal, the national expert provided a brief summary report of an survey carried out on purpose for the InGenious report to explore S-I initiatives but did not include references to research studies or reports, and therefore no information on research developments in Portugal could be included in the present study.

[4] For additional details, please contact to ingenious@eun.org

[5] Belgium expert was appointed also for France report

This document has been elaborated based on the abstracts collected from the experts about the identified research studies, reports, reviews and/or official documents (not on the original publications). However, as already pointed out, the information provided by some abstracts was more oriented to methodological details or general goals and did not allow having enough insight on main results or conclusions.

The report is structured under two main sections. The first one is not directly related to STEM S-I partnership, but includes a set of relevant studies and reports related to students' career choices, gender issues, STEM competences and skills needed in the world of work. The second section is more focused on the exploration of existing S-I links, including general reviews, evaluations and outcomes of particular initiatives, and reports about the role and perspectives of industry and school in the promotion of STEM careers.

On the other hand, a great number of projects and programmes (campaigns, educational initiatives, activities of informal education, etc.) have been reported by the national experts through the process of data collection. Since the aim of this report was to review national research developments but not to collect examples of particular STEM-related S-I initiatives, this information has not been included. However, these projects and programmes (which can be considered to be included in the existing repository of practices already developed within the project) are listed in Annex III, since the reader might be interested to know about their existence.

1. Career choices and STEM competences

During the last years there has been an increasingly concern in most western countries about the fact that current and future shortages of qualified STEM professionals might represent a disadvantage for the progress of their economies. It should be kept in mind, however, that not all STEM professionals are equally demanded (see Table 2) and that the shortages might be particularly important for certain sectors in different countries[6]. Although absolute numbers of science and technology have been rising in line with access to higher education, their relative share has been falling in tertiary education (Figure 1) and upper secondary levels in several OECD countries (OECD, 2008). In this respect, a recent report on reindustrialising Europe to promote competitiveness and sustainability (Bütikofer, 2013) highlights the need to more and better access to training, lifelong learning, fit-for-the-future vocational training and university education, placing special emphasis on the STEM fields and entrepreneurship support. In fact, the lack of STEM-skilled labour has been highlighted as one of the main obstacles to economic growth in the coming years, something which has lead the business sector to address the issue on how industry can help to do something about the shortage in STEM studies and careers (Business Europe, 2011). This concern is also expressed in a recent report which collects the views of 100 CEO Leaders who were interviewed on how they see the future of STEM and how their companies and industry contribute to promote them (Fraser, 2013).

Table 2: Anticipated future employment demand in key STEM-related sectors, **EU-27**, 2010-2020 (Table retrieved from EU Skills Panorama, 2012).

	2010 (000s)	**2020 (000s)**	**Change 2010-2020 (%)**
Pharmaceuticals	494	493	0.0
Chemicals not specified elsewhere	1,168	1,169	0.1
Non-metallic Mineral Products	1,618	1,549	-4.3
Mechanical Engineering	3,453	3,644	5.5
Electronics	967	980	1.3
Electrical Engineering & Instruments	2,750	2,780	1.1

[6] Some country-specific demand developments and trends (regarding Austria, Belgium, Germany, Hungary, Ireland and Italy) are briefly described in the STEM Skills Analytical Highlight prepared by ICF GHK for the European Commission (EU Skills Panorama, 2012).

Motor Vehicles	2,208	2,164	-2.0
Manufacturing not specified elsewhere	2,204	2,206	0.1
Communications	3,011	3,156	4.8
Computing Services	3,040	3,270	7.6
Professional Services	7,530	8,578	13.9
All industries	223,219	230,847	3.4

Source: Cedefop (2012)

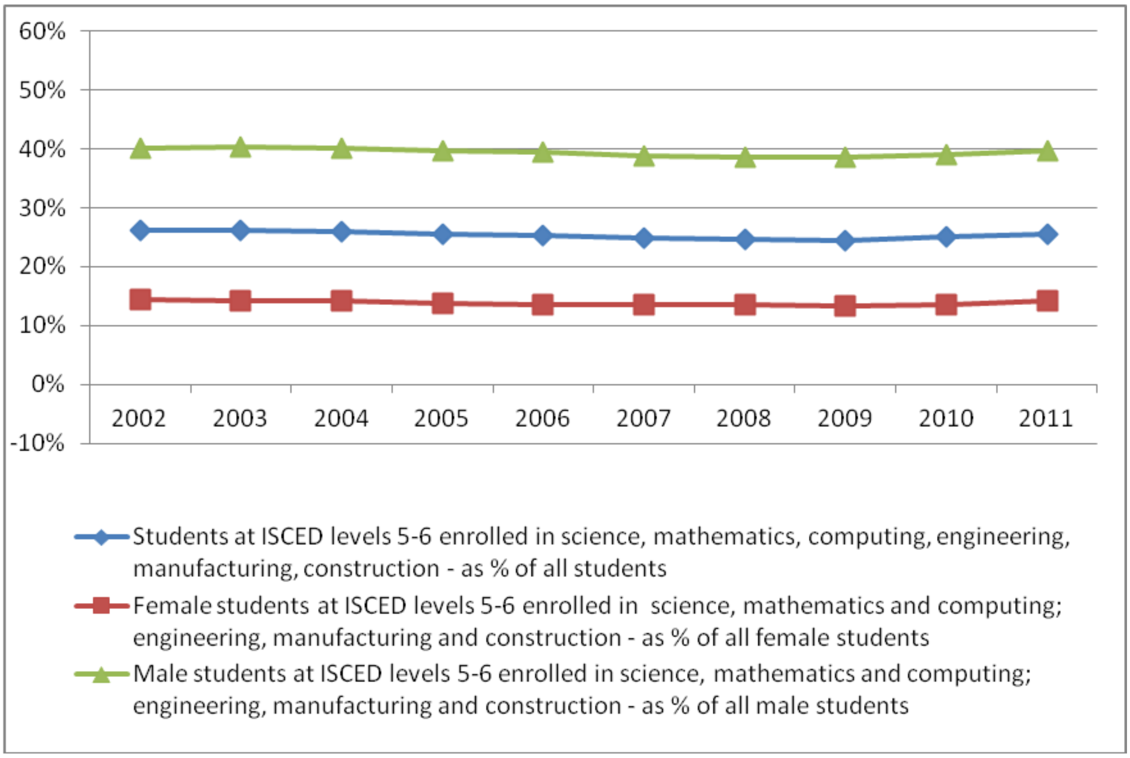

Figure 1: Tertiary education graduates in Maths, Science and Technology as % of all fields (EU-27 countries). Source: Eurostat Statistics (Population and social conditions/Education and training/Database/Education indicators – non-finance/Tertiary Education Graduates (educ-itertc). Last update 11.06.13 / Extracted on 26/06/13.

With this in mind, and in order to design interventions that can contribute to improve this trend as effectively as possible, it is important to explore which are the **students' attitudes towards STEM careers** in order to be able to identify ingredients involved in the process of career choice. Some studies performed with this purpose were identified at national level, one of them in Spain, another one in Israel and two more in Estonia.

According to the authors of a study carried out in Spain (Marco, S. and Garriga, J., 2012), in order to thoroughly understand the current decline of high school students choosing to pursue majors in STEM the views of the protagonists themselves must be considered. The mentioned study was conducted within the participation of more than 4700 students aged 14 to 18 from public and private schools at regional level in both urban and rural settings and different socio-economic backgrounds. Based on the key findings, four main challenges to increase STEM vocations are highlighted:

- Increase the interest and motivation for STEM in primary education and make these disciplines more attractive in secondary education.
- Improve career orientation about STEM studies in secondary education.
- For both primary and secondary, work on breaking the Pygmalion effect (self-perceived capability as a limiting factor to study STEM) and strengthen the pleasure to learn STEM, reinforcing the circle "I like it; I'm good at it; I feel capable".
- Change masculine stereotypes of STEM careers and increase the visibility of female role models and referents in these fields.

Likewise, two research studies were identified in Estonia, one focused on the social image of researchers and engineers, and the other one focused on students' evaluations of physics science shows.

The latter corresponds to a Bachelor's thesis which explores evaluations and ratings that students gave of a science show and of the learning on physics and natural sciences derived from having seen the show performance (Jaansalu, 2013). Although this study was not performed upon any initiative involving S-I collaboration, it is worth highlighting some of its findings, which show that: (i) students think physics and other sciences are necessary, but boys and girls feelings differ about physics; and (ii) attractiveness of physics show is related to students' ability to apply their knowledge.

The other Estonian study (Meiesaar, 2010) is a master thesis in which the author sought answers to three main questions: (i) how do young people represent researchers and engineers? (ii) what are their attitudes towards the related careers? (iii) what kind of discursive schemes are constructing these attitudes? As the main results of the study, it was found that:

- Young people consider researchers and engineers to be very clever and intelligent, really important for the society. They are represented as energetic actors, although at the same time, on the basis of individuals young people stigmatized them and emphasized their exceptionality.
- The central criterion in career choices is high personal interest, and individualistic-discursive choices are strongly connected with the social identities considered to be "normal".

- The social image of researchers and engineers and the attitudes towards the related careers are influenced by traditional gender roles.
- It is necessary to re-contextualise young people's concept of success linking it with using one's interests and abilities, to bring down the stereotypes.

The image of "the scientist" and its effect on the willingness to be a scientist and to follow a career in science were also investigated in a comparative study in Israel (Koren and Bar, 2009). Two different cultural populations of elementary and junior high school pupils in Israel were considered: Hebrew-speaking pupils and Arabic-speaking Bedouin pupils. The results showed that the image held by Hebrew pupils was similar to those held by western pupils found in previous results. The image held by the Arabic pupils, however, differed from that found in previous research. This image had a strong cultural trend, with Golden Age Muslim scientists' names dominating the list, and drawings of traditional Muslim figures. Another image found in their drawings was that of a scientist admired as a teacher, emphasizing the Bedouin school's formal culture.

Some studies performed at national level have specifically been focused on **gender issues** related to STEM, such as the one presented in a report by the Dutch National Expert Organisation on Girls/Women and Science/Technology (Booy, Jansen, Joukes and Van Chaik, 2012). In particular, this document addresses the following questions within the Dutch context: (i) What do we currently know about gender and STEM? (ii) Are more girls and women now choosing STEM? (iii) What is the situation with regard to gender and STEM in other countries? (iv) What have universities done over the last few years with regard to gender and STEM? (v) What do graduates consider to be important in a STEM study programme? (vi) Does a greater focus on women and STEM provide any economic benefits? (vii) Does the gender balance in STEM need to be improved further? (viii) How to proceed? Regarding the last question, it is worth mentioning that the document highlights some preconditions for universities for the development of policy and activities designed to successfully attract, retain and ensure the graduation of both female and male students. These are:

- Chain approach: Collaboration with all relevant parties: secondary education, the STEM business community and other partners within the region.
- Integrated approach: An approach that simultaneously tackles all fronts, designed to attract and retain female students and ensure the successful progression onto the STEM labour market. An individual focus on either intake, or progression, or graduating students is not effective in the long term.
- Longitudinal approach: Not a collection of one-off uncoordinated activities, but instead a sound long range strategy which is regularly evaluated in terms of effect and process, and adjusted in the interim where necessary.
- Gender expertise: The appointment of a 'gender expert' with specific tasks or a gender core team within the STEM study programmes. Reorganisations have meant that many STEM faculties no longer have staff officers who are responsible for and have expertise in equal opportunities, however the period in which equal opportunities coordinators were indeed active within universities was highly productive: there was a gradual increase in the percentage of female students over this time.

- Gender mainstreaming of policy and activities: It is important that STEM study programmes examine for all policy intentions and resulting activities whether these are equally effective for both female and male students.
- Specific gender policy: Where there is a severe gender imbalance in the student population, additional measures to redress the balance must be taken for as long as this situation persists. An explicit focus must temporarily be placed on the target group, for instance information activities specifically aimed at girls in secondary education who are the potential next generation of female STEM students, and separate activities or provisions for female students.

Another study was performed in Germany about an example of professional mentoring designed to encourage girls to choose a job in a scientific, technical or IT-related field. According to the authors of the study (Quaiser-Pohl et al, 2012), girls and young women in Germany are unable to take full advantage of their superior educational credentials when entering the job market. It appears that women are faced with a narrower field of career choices and they tend to select occupations with lower salaries and fewer opportunities for career advancement. In this context, at the transitional point between college or university and work, job entry mentoring is often used to help people get jobs, but it is rarely used to support the transitions involving occupational training. In their article, the authors present the latter type by the example of the "occupational education" branch of the Ada-Lovelace-Project[7], describing special features, prospects and limitations of this form of mentoring.

In line with the topic of the gender gap in STEM, there is a worth mentioning study performed in Norway which explored a research project aiming to contribute to improving recruitment, retention and gender equity patterns in STEM education and careers (Sinnes and Løken, 2012). The article argues that adjusting science subjects to match perceived typical girls' and boys' interests risks being ineffective, as it contributes to the imposition of stereotyped gender identity formation thereby also imposing the gender differences that these adjustments were intended to overcome. The authors also point out that some recommendations made to address the gender issue might have only a "cosmetic character", and that more fundamental changes to the practices and priorities within STEM subjects and fields are required to recruit more diverse people to these fields.

1.1 STEM education: some remarks

Apart from the studies previously mentioned, which are mainly focused on psychological and sociological perspectives, a wide body of research has been published at international level in the field of science education and didactics, providing very useful results which should be taken into consideration when designing S-I initiatives that can positively contribute to the acquisition of scientific and mathematic competences (i.e. Brandford *et. al.*, 2000); Osborne and Dillon, 2010).

Frequently based on this research, a great deal of reports, reviews and white papers have been published worldwide which, despite not being focused on STEM-related S-I partnership, provide frameworks and recommendations that constitute a good basis for the development of initiatives

[7] http://www.ada-lovelace.com/

which can contribute to a better understanding of key concepts by students and to increase their interest in STEM careers. This is the case, for example, of a report published in the USA which provides an overview of K-12 (primary and secondary) STEM education (Hanover Research, 2011). It presents STEM-focused schools, which are said to find innovative methods for structuring the curriculum, develop instructional techniques, recruit highly-qualified teachers, provide opportunities for extracurricular activities, and foster connections with the professional STEM community. In the report it is stated that implementation should include careful research, a long planning process, and a detailed blueprint of the STEM program, and that a coherent and rigorous curriculum that focuses on depth rather than breadth is essential for any successful STEM school initiative (better to focus on teaching few but fundamental ideas instead of teaching collections of fragmented concepts and series of disconnected facts). Pedagogical techniques used in STEM-focused schools include project-based learning, workplace or lab-based learning, the use of technology-supported learning tools, as well as traditional, teacher-led instruction. It is also affirmed that one way to motivate students and cultivate their interest in STEM subjects is to offer them various extracurricular activities and that professional development for STEM teachers should persist over an extended period of time. Surveys of teachers, mentioned in the report, suggest that teachers were most interested in STEM-focused professional development that emphasized career awareness, inquiry based activities, and interdisciplinary activities, and that visits and tours or workshop activities were the most preferred modes of delivery.

Another more recent report presents a new Framework for K-12 science education in the USA which is, according to the authors, the foundation for the upcoming Next Generation Science Standards (NGSS) (Schweingruber, Quinn, Keller and Pearson, 2013). The framework, which was built on the fusion of expert science knowledge and leading research in the teaching and learning science, is stated to offer a new vision where students experience science in the classroom, combining traditionally-taught core ideas with science and engineering practices and crosscutting concepts.

It is also worth mentioning that, in Australia, a recent report was published collecting the results of a project aimed at exploring what different countries are doing to develop participation and performance in STEM disciplines and the take-up of STEM in the labour market and research system (Marginson, Tytler, Freeman and Roberts, 2013). The findings highlight a number of STEM issues, emerging from the country reports and international comparisons, together with examination of STEM in Australia, that are key topics for discussion at the national level. These are STEM in Society, Attitudes to STEM, Framing National STEM policy and strategy, School curriculum and pedagogy, Teachers and teaching, Labour Markets and STEM, Girls and women, STEM and indigenous students, Partnerships and enrichment activities and National STEM coordination.

At European level, the Dutch and the Belgian experts highlighted two very popular documents, already considered in previous InGenious documents. Due to the influence of these documents and the fact that both experts mentioned them, it has been considered interesting to recall some of their main results. The first one is a report based on the work performed by a group of experts (tasked by the European Commission) who examined a cross section of ongoing initiatives to draw from them elements of know-how and good practice that could bring about a radical change in young people's interest in science studies (Rocard, 2007). The authors point out that, even though the science education community mostly agrees that pedagogical practices based on inquiry-based methods are more effective to improve the way science is taught in schools, the reality of classroom practice is that in the majority of European countries these methods are simply not being implemented. Thus, although the current initiatives in Europe actively pursuing the renewal of science education through “inquiry based” methods show great promise, they are not on a scale to bring about substantial results, and are not able to fully exploit the potential European level support for dissemination and integration.

On the other hand, the second report develops seven recommendations to enhance STEM education (Osborne and Dillon, 2008), two of which are particularly relevant for the development of STEM-related S-I partnerships:

- EU countries should ensure that: (i) teachers of science of the highest quality are provided for students in primary and lower secondary school; (ii) the emphasis in science education before 14 should be on engaging students with science and scientific phenomena. Evidence suggests that this is best achieved through opportunities for extended investigative work and “hands-on” experimentation and not through a stress on the acquisition of canonical knowledge.
- Good quality teachers, with up-to-date knowledge and skills, are the foundation of any system of formal science education. Systems to ensure the recruitment, retention and continuous professional training of such individuals must be a policy priority in Europe.

Also within the European context, existing challenges and national policies in Mathematics Education, as well as national practices, policies and research in Science Education have been explored in two recent reports written by national Eurydice Contributors (Eurydice, 2011a; Eurydice, 2011b). In the first case, an overview of the policies and initiatives to increase student motivation in learning mathematics is provided (in Chapter 5 – Improving Student Motivation), presenting national strategies and practices for fostering positive attitudes towards STEM-related subjects. Among these, innovative teaching methods, school partnerships with universities or businesses, and extra-curricular activities targeting talented students in particular are included. The report on Science Education gives an overview (in Chapter 2) of current approaches to and measures in place for raising interest in and motivation for science. It also presents national strategies in place in European countries for promoting science education and deepens the topics of school partnerships, science centres and guidance measures. In line with this, a comparative analysis on national measures taking place in 21 European countries to increase students’ interest in pursuing STEM studies and careers was performed and published in a report (Kearney, Wastiau, Gras-Velázquez, Grečnerová and Baptista, 2011).

Finally, a research paper by Dutch authors has been published highlighting the **importance of mathematical skills in the labour market** and the need to promote them from the early school (Hoyles *et. al.*, 2010). The authors argue, based on a series of case studies from the manufacturing and financial service sectors, that there has been a radical shift in the type of mathematical skills required for work – a shift not yet fully recognised by the formal education system, or by employers and managers. Examining how information technology has changed mathematical requirements, the idea of Techno-mathematical Literacies (TmL) is introduced to describe the emerging need to be fluent in the language of mathematical inputs and outputs to technologies and to interpret and communicate with these, rather than merely to be procedurally competent with calculations. The authors argue for careful analyses of workplace activities, looking beyond the conventional thinking about numeracy, which still dominates policy arguments about workplace mathematics.

1.2 Research results on STEM educational practices

In the Netherlands, several studies have been performed regarding the **potential benefits of using authentic practices as contexts for teaching and learning** in different areas, such as ecosystem behaviour (Westra, 2008), chemistry (Prins, 2010; Meijer, 2011), inferential reasoning (Dierdorp, Bakker, Eijkelhof & VanMaanen, 2011) and biology (Moolenbroek, 2012).

Without going into the particular key findings of each of these studies, some remarks that are highlighted should be considered as relevant for STEM-related S-I partnerships:

- For education to be effective, students should be willing and enabled to take an active role in the learning activities (Westra, 2008).
- An authentic practice is a valuable, rich source of inspiration for designing teaching-learning processes. The educational challenge is to adapt the practices to suit students' abilities and lead to desired learning outcomes (Prins, 2010).

In line with this study, there is a report from the "Techno-mathematical Literacies in the Workplace" project (Bakker *et. al.*, 2005) in which the authors state that the training of de-contextualised mathematical ideas has long been recognised as a problematic approach to effective skills development where mathematical skills are required in workplaces. In this sense, and defining "learning opportunities" as flexible resources for mathematical learning that can be incorporated within workplace technical training materials, and are situated within the contexts and artefacts of the workplace, the authors explain how their approach may contribute to more effective training practices.

Similarly, there are two **studies about science laboratory activities as learning experiences** that could be taken into consideration when thinking of the design of new activities. The first one (Hofstein and Lunetta, 2003) is a review of the literature associated with laboratory/practical work in science education. The researchers insist that more appropriate research methodologies and technology resources are now available to support research on how to help students and teachers attain the goals for science learning that data show have been difficult to achieve. They also emphasize the importance of providing support for teachers to collaborate with colleagues in the science education research community so as to understand, develop and teach in ways that are consistent with contemporary professional standards. The second one is an intervention study in vocational education developed in the Netherlands in which the use of a visual tool that foregrounds mathematical aspects of laboratory work illustrates how vocational mathematical knowledge can be developed effectively and efficiently (Bakker, *et. al.*, 2012).

On the other hand, the relationship between school and industry has been shown to be relevant from the perspective of **entrepreneurial learning**, which has been suggested as one possible way to increase students' interest in science and technology (Sagar, 2013). However, and as pointed out in the Swedish thesis just cited, teachers may need inspiration and support to provide entrepreneurial learning environments for their students. This support can be provided by

Continuing Professional Development (CPD), which can help to expand teachers' competences in authentic and entrepreneurial teaching issues in Science and Technology (Sagar and Mehli, 2013). Nevertheless, collaboration with the surrounding world (including industry) in the teaching practice is one of the components which may be included in entrepreneurial learning, although teachers perceive requirements and barriers for integrating collaborations (Sagar, Pendrill and Wallin, 2012).

In this sense, a selection of practical recommendations to enable teachers for entrepreneurship education is available in the Guide for Educators published by DG Enterprise and Industry (DG Enterprise and Industry, 2013). This guide was the outcome of two events organised along 2012 (one in Dublin, Ireland, and another one in Brdo, Slovenia) by DG Enterprise and Industry and DG Education and Culture, and focuses on entrepreneurship education which aims to promote next to entrepreneurial competences various other of 8 key competences for lifelong learning, i.e. the mathematical and scientific competences.

2. STEM School-industry partnerships in education

The studies and reports previously discussed highlight the need to give support to STEM education by providing real contexts and promoting the skills needed for the future works. In this sense, S-I partnerships have a huge potential to contribute to this aim, especially to provide young people with first-hand information about STEM careers which can enhance their career education. Actually, in countries such as Australia, the USA and the United Kingdom, there is quite a long tradition in the collaboration between the world of work and compulsory education, and several studies exploring existing initiatives have been published (Watters and Diezmann, 2013; Kisner, Mazza and Ligget, 1997; Iredale, 1999). Many publications which deal with particular initiatives involving S-I collaboration in the UK have been identified by the corresponding national expert, much more than in the rest of countries involved in this gathering process (Straw and Dawson, 2012; Holman and Finegold, 2010; Finegold, Stagg and Hutchinson, 2011; Collins, 2013; Education and Training Inspectorate, 2010; Department for Employment and Learning, 2011; Department for Employment and Learning, 2012). However, and for the sake of convenience, these will not be covered in detail in the present document and we will mainly focus on general reports having a broader scope.

As an example, a research on S-I links was commissioned by Futurelab to carry out a review of the character and effectiveness of existing employer engagement initiatives in the UK STEM education (Mann and Oldknow, 2012). Three main delivery routes for employer engagement in STEM education activities in England were identified:

- National intermediary organisations
- Local intermediary organisations
- Direct relationships between schools and employers.

The review draws on information from a National Audit Office review undertaken in 2010 (Educating the next generation of scientists, available at http://www.nao.org.uk/wp-content/uploads/2010/11/1011492.pdf) which highlights some areas of progress including reversal of a decline in number of young people taking STEM subjects in schools, and uptake of key programmes such as the STEMNET[8] STEM Ambassadors programme. While echoing the National Audit Office concern about the weakness of career provision related to STEM, the review suggests there is a broadly positive feeling in the UK about the use of employer engagement as a means to promote STEM take-up and achievement.

In another research study carried out by the National Foundation for Education Research (NFER) and commissioned by STEMNET, the engagement of STEM small and medium sized enterprises (SMEs) with education in the UK was explored (Harland *et. al.*, 2012). As stated in the report, although there is a long history of links between education and industry in the UK, much of this

[8] STEMNET is a national organisation with regionalised structure which receives funding from the UK Government Department for Business, Innovation and Skills, the Department for Education and the Gatsby Charitable Foundation.

work has involved large companies, and the engagement of SMEs has been seen as a major challenge, since their small size leaves little flexibility to find time or staff to engage with education. A top-level review of evidence and interviews with 53 SMEs in a range of STEM sectors across the UK was carried out by NFER in this piece of research, and some of the main key findings are the following:

- There is a relationship between size of business and the extent of engagement; smaller businesses are less likely to engage, and to engage on a more *ad-hoc* basis and with a narrower range of activities, often due to the lack of dedicated human resources staff.
- The most common types of engagement are: links with universities and colleges; offering work experience; and involvement in specific schemes and projects (e.g. STEM Ambassadors, Young Enterprise).
- There are a range of benefits to employer engagement in education including: enhancing the skills' pipeline and recruitment to the sector; staff professional development and increased enjoyment and motivation; promoting the company's image; capitalising on young people's ideas; and the opportunity to "give something back".
- Business face a range of challenges in engaging with education including: time, capacity and financial constraints; low awareness and understanding of schemes and how to link with education; difficulties in engaging schools; health and safety constraints and bureaucracy; low awareness of the benefits of engagement; and difficulties in appropriately pitching activities and relating them to the curriculum.

A White Paper on the Future of STEM Education in the UK has been recently published by the National Science Learning Centre (NSLC, 2013). The report describes the key elements arisen from a discussion established between head teachers, teachers, academics, scientists and representatives from business and industry on how to accelerate the improvement of STEM education, and lists the recommendation arising from it. Two of them are specifically related to S-I collaboration:

- Supporting the provision of funded opportunities for partnership working, including placements, sabbaticals or engagement in collaborative research with universities, business and industry.
- Giving incentives to schools and colleges to provide an enriched and enhanced STEM curriculum, including links with employers, quality practical experiences, and research in schools in order to maximise positive impacts on pupil achievement.

Another report produced by the Science and Engineering Education Advisory Group (SEEAG) in Scotland provides an in-depth account of recent and current thinking about STEM and STEM education in Scotland, and how this relates to the wider STEM employment sector and culture (SEEAG, 2012). The report contains many references to collaboration between education and industry in providing opportunities for learning about STEM and STEM careers, including a section on "support from industry". It also discusses some types of engagement by industry with schools, and gives high priority to industry working in partnership with providers of continuing professional development. The report recommends that industry provides support through the main “providers” or agencies specialising in liaison with schools (e.g. local authorities, and programmes such as STEM Ambassadors and Young Engineers) rather than by working with schools on an individual basis, arguing that this will provide more strategic, coherent collaboration between schools and industry, and will make opportunities more widely available, with better quality control and evaluation. There is also a number of recommendations in each of its eight parts, providing comprehensive coverage of how STEM education, STEM career-related learning and collaboration with industry fits within the broad national strategy for STEM in Scotland.

On the other hand, the role of school leaders (head teachers and their senior staff) in relation to school’s engagement in several STEM-career related areas has been also explored in the UK. According to the results of a research conducted by the International Centre for Guidance Study at the University of Derby (Hutchinson, J. 2013), the presence of STEM employers in the community local to the school can shape how the school builds its STEM career-related learning activities. In this sense, schools that are part of a local economic community which is built on STEM-related industries are better placed to take advantage of links with STEM employers than those in economic areas dominated by non-STEM industries. However, the research found that the local presence of STEM employers did not guarantee that a school would engage with them. It was also pointed out that schools without an obvious STEM employer presence in their locality could still become engaged with STEM industry in other ways, although the key appears to be the commitment of the school senior leadership and the extent to which they prioritise STEM career-related learning. Two of the recommendations made in the report are:

- Teachers who design, implement and manage STEM career-related learning initiatives need to be allocated time, responsibility and esteem.
- Teachers who have wider work experiences should be encouraged to share their learning and contribute their skills to support STEM career-related learning opportunities.
- Head teachers should allocate time to inform all teaching staff of the career-related learning that occurs within school, and should facilitate further training for STEM leaders on general sources of careers information and on the nature of STEM careers.
- STEM career-related learning should be undertaken for all young people in secondary school.

In line with this, a report was prepared by the Scottish Science Advisory Council where they explored ways in which the links between schools, universities and business can be enhanced to support science education in Scotland (Scottish Science Advisory Council, 2011). A list of ten recommendations was given along the report, the following ones being especially relevant for S-I partnerships:

- CPD should be developed further to include the full range of science-related CPD opportunities available (including those available via industry).
- There should be a greater role for industry and academia in developing and contributing to science-specific CPD for science teachers.
- There should be a greater role for industry in educating teachers, particularly career advisers and guidance teachers, and parents/carers about the wealth and diversity of STEM-related careers.

The need for cooperation between the education system and the business sector was also emphasized in a report published in Israel, which states that at present there is no real coordination between the needs and demands of employers and the supply in the labour market, and that the involvement of the partner companies is very limited (Hachmon & Eisenberg, 2010). The report also states that the wider picture of the contribution of industry to education in the long term is lacking and most of the cooperation is undertaken on the basis of adopting company's social commitment rather than from the viewpoint of the benefits that may be derived from such cooperation. In this sense, some recommendations are given on how to facilitate the cooperation between these two worlds:

- To create a legislated inter-ministerial body to institutionalise the various activities of cooperation at every level of education with the business sector, and to provide this body with a long-term budget.
- To reduce governmental bureaucratic procedures.
- To ensure the efficient use of all the available resources, governmental and otherwise, and the rational utilisation of human resource potential in order to close gaps between supply and demand, and between the needs of employers and trained human resources.

Another report was funded by Google-Israel to investigate ways to advance innovation in Israel and to empower its economy through the use of ICT in the public sector (E-nnovate Israel, 2013). It highlights that Israel is much less advanced in the use of technology in the public sector than other countries, and that the increase in the use of ICT in the public sector relies on individuals with computer literacy and computer based skills. The report lists steps taken in the past to encourage Israeli junior high and high school students to study STEM, and presents recommendations that might enable the state to preserve its present prestige as innovator. In this context, it is pointed out that vocational and technological education need to be planned and monitored, STEM studies need to be encouraged, students' interests examined, and academic excellence in STEM ensured through the establishment of greater links between academia and industry. Moreover, mention is made of peripheral populations who traditionally do not choose STEM but should be recruited and assisted. The report also states that the weakening of the Israeli school system in the last 15 years, the dwindling of vocational studies and the decrease in funding for research in Israeli academia are all obstacles that need to be addressed in order to bring about the necessary change in the use of ICTs in the future.

On the other hand, there is a compendium of best practice promoted by a multinational company which shows an example of public-private partnerships in the United States addressed to improve education and bolster students' achievement in STEM (Bayer Corporation, 2010). According to this compendium, a STEM education program should meet a set of criteria. These criteria are based on guidelines provided by the US Building Engineering and Science Talent -BEST- Commission, National Science Education Standards and National Science Resources Center:

- Challenging Content/Curriculum: an inquiry-based, experimental curriculum that is clearly defined and understood
    - Related to real-world applications;
    - Encourages critical thinking, problem solving and team working;

  - Goes beyond minimum competences;
  - Reflects local, state and/or national standards;
- An Inquiry Learning Environment: an environment where teachers and their students work together as active learners
  - Teachers have access to and time allotted for professional development that hones their science knowledge and experimental teaching approach;
  - Necessary curriculum materials are supplied in full;
  - Students' diversity, individuality and uniqueness are recognized and respected;
- Defined Outcomes/Assessment: goals are clearly identified and success is measured against them
  - Assessment tools are designed to measure outcomes;
  - Assessment provides:
    i. Both quantitative and qualitative information;
    ii. Basis for research and continuous improvement of program;
- Sustained Commitment/Community Support: program has strong leadership and sufficient resources:
  - Continuity of program funding;
  - School and/or school district support;
  - Community support, including parents and private industry;

More recently, a White Paper was published proposing an example of business-education collaboration in the United States, which involves the creation of a new facility (a STEM Innovation Centre) that would provide opportunities for STEM-related business and industry investors, non-profit organisations, private entities, and higher education agencies to offer on-campus instruction, mentorships, internships, cooperative learning experiences, and work study programs for high school students to gain real-world experiences in the workplace (Kerr, 2013).

In Australia, school-industry partnerships have been also extensively studied. In a recent paper, a set of four case studies of partnerships designed to enhance student interest in STEM was reported (Watters and Diezmann, 2013). The descriptive multiple case study approach adopted in the paper provides a retrospective account of selected cases of interest which were identified in a series of ongoing evaluation projects. The key finding is that the formation of relationships and partnerships, in which students have high degree of autonomy and sense of responsibility, is paramount to positive dispositions towards STEM. The authors argue that, although the study draws on experiences in one educational jurisdiction, it has significance for planning and implementing effective strategies to engage students in the foundations of STEM education.

Finally, another recent document was published by the OECD sketching lessons for promoting educational innovation through collaboration (Kärkkäinen and Vincent-Lancrin, 2013). The report explores the case study of the HP Catalyst Initiative –an education grant programme by the Hewlett-Packard (HP) Sustainability and Social Innovation team– and highlights five technology-supported pedagogic models (gaming, virtual laboratories, international collaborative projects, real-time formative assessment and skills-based assessment) in STEM that have the potential to improve students' learning outcomes, including higher-order thinking skills. It also outlines lessons for policy-makers and other stakeholders willing to promote educational innovation through collaboration, in order to foster knowledge flows, new ideas and peer learning.

- Boost collaborative innovation by early face-to-face interactions and targeted funding.
- Provide support to build capacity for quality, efficiency and sustainability.
- Use monitoring and feedback for adjustment and improvement.
- Either define consortia in detail or allow free consortium formation to enhance collaborative innovation.
- Map project objectives, methods and expected outputs at the start to facilitate collaboration.
- Communicate the monitoring and evaluation metrics early on.
- Consider possibilities for comparative evaluation in the design of the initiative.

2.1 Some outcomes and evaluations of initiatives involving S-I collaboration

As suggested by some of the reports mentioned above, when implementing an educational initiative, it is important to have in mind the need to evaluate if the intended outcomes have been properly achieved. This not only allows to check the effectiveness of the invested efforts, but also to put forward measures to redefine the initiative in case the expectations were not accomplished. In this sense, in the frame of the inGenious project an evaluation process has been designed and implemented under work packages WP3 and WP6 with the aim of analysing the impact of several S-I practices that were piloted in the partner countries (Kudenko and Gras-Velazquez, 2013). Among other findings of this research, the results showed that (i) interest in STEM subjects and enjoyment of lessons are necessary, yet not sufficient factors in fostering STEM career choices of secondary pupils; and (ii) including activities at school addressed to make students learn about different career choices available in industry, science and technology increases 20% students' interest in getting a job related to science and technology.

On the other hand, within the information provided by the national experts, several reports have been collected which present some outcomes on the impact of particular initiatives involving partnerships between schools and companies. In the UK, for example, a research study aimed at evaluating the impact of STEMNET's services on pupils and teachers, the evaluation being focused on STEMNET's three key programmes: (i) the STEM Ambassadors Programme; (ii) Management of After-School Science and Engineering Clubs (STEM Clubs);

and (iii) Brokerage of STEM enhancement and enrichment activities – linking schools with STEM organisations in industry, etc. (Straw, Hard and Harland, 2011). The evidence gathered during the evaluation activities showed that STEMNET's services are perceived to be of a high quality, and that they are leading to a range of positive outcomes for both teachers and pupils. Notably, involvement in STEM Clubs and/or interactions with STEM Ambassadors is increasing pupils' interest in STEM, as well as developing their knowledge of the subjects, practical skills and generic transferable skills (e.g. team-working, problem-solving) which are of key importance to their future employability. The report also showed some evidence that involvement in STEM Clubs and interaction with STEM Ambassadors can increase attainment in STEM subjects and progression to STEM subjects. In relation to STEM Ambassadors, the evaluation suggests that more ongoing and sustained contact with STEM Ambassadors could lead to even greater impacts for pupils. The evidence also suggests some issues to consider in the future, in particular relating to the place of mathematics within STEM. However, this is of relevance not only to STEMNET, but also to the wider community of organisations involved in STEM education.

Similarly, the Tomorrow’s Engineers programme, led by the organisations Engineering UK and the Royal Academy of Engineering, and aimed at raising engineering career awareness through extra-curricular engineering activities delivered by a range of partners to young people in targeted schools across the UK, was evaluated by the National Foundation for Education Research (NFER) in order to determine the impact of the programme and areas of effective practice (Stevens, Everett, MacLeod and Straw, 2013).

Some studies that have been identified in other countries are more focused on vocational education (where S-I collaboration is well established) and make emphasis on the educational effect of internships. For instance, a Dutch study presented at the ECER VETNET Conference in Berlin (Mazereeuw and Boersma, 2010) was performed to gain insight on the problems that students have in connecting their learning in work placement and in school. Other studies stress on potential learning mechanisms that are related to the learning activities and competence development during practice periods (Akkerman and Bakker, 2011; Van der Sanden and Teurlings, 2003).

According to Akkerman and Bakker (2012), although apprenticeships have been identified as valuable learning and working trajectories for successful transitions and relations between school and work, they have been mostly located as activities taking place solely in the workplace with hardly any attention for what students do and learn during release days at school. Within their research, they conducted workplace visits and analyzed how apprentices’ experiences at work are discussed and reflected upon with students and teachers at school, and based on the results, they discuss how school and work institutions can mutually feed each other in facilitating apprentices’ learning.

Similarly, a study presented at the Conference proceedings ICME 2012 aimed at helping apprentices in secondary vocational laboratory education integrate the mathematics and statistics learned at school with work-related knowledge (Bakker, Van Mierlo and Akkerman, 2012). Within the followed approach, the apprentices refreshed their statistical knowledge (e.g. correlation, regression, variation coefficient) in relation to the work task of comparing two measurement machines (including linearity, stability, reproducibility). The results revealed that the level of integrating the mathematics and statistics learned at school with work-related knowledge increased significantly.

On the other hand, the combination of technical knowledge with entrepreneurship education has been also explored within the Engineer-Entrepreneur program, a start-up-oriented program applied at a school of engineering in Israel (the Shamoon College of Engineering) which integrates key elements in education and entrepreneurship (Yemini and Haddad, 2012).

Evaluations have been performed as well for some existing initiatives in Germany which are specifically focused on positively influence girls’ vocational choices towards STEM.

One of these initiatives is a one-year personal mentoring program for eleven to eighteen-year-old female college-preparatory students in STEM. This program involved communication between mentee and mentor with one another and with other program participants (via email, online chat, and forums), and according to the evaluation results, greater levels of desirable short-term and long-term developments were shown by the treatment-group participants (Stoeger, Duan, Schirner, Greindl and Ziegler, 2013). Another report was published on the evaluation of the "*Forscherinnen-Camps*" (researcher camps), a German initiative organised in Bavaria in cooperation with companies and universities and addressed at girls aged between fifteen and eighteen years old (Bildungswerk der Bayerischen Wirtshaft e.V, 2011). According to the reported results of retrospective questionnaires and interviews with participants, (i) getting practical experience was identified as a central motivation for participation, and (ii) during the camps girls developed a more positive technical self concept.

3. Conclusions

The present review of country reports on STEM-related school-industry partnerships allowed us confirming many of the ideas that had already been identified along the whole study performed within WP2. In general terms

- There is a shared concern in Europe and other western countries about the importance of having a well-qualified STEM workforce for the economic progress. The existence of several policies and frameworks addressed to improve STEM education to enhance citizens' literacy and to increase young people's interest in STEM careers reveals this concern;
- Apart from improving STEM education, there is a need to address other factors which influence students' attitudes toward STEM careers (paying special attention to target groups, career orientation and gender issues);
- School-industry is seen as a way of positively contribute to the goal of promoting STEM vocations among youngsters, and Anglo-Saxon countries (UK, Australia, USA) have quite a long tradition in developing this kind of links;
- Many initiatives involving school-industry links are promoted across Europe, although not uniformly distributed (in Northern countries they tend to be more frequent than in Southern and Eastern ones);
- There is, in general, a lack of research studies at local level addressed to evaluate the impact or the outcomes of these initiatives (although again, in North-European countries evaluation studies are more frequent than in South and East-European ones).

More particularly, some highlighting remarks arisen from this country reports review and which also reinforce our previous findings should be taken into consideration to promote young people's interest in STEM careers through initiatives involving S-I collaboration:

- It is necessary to work, for both primary and secondary education, on promoting students' self-efficacy (i.e. by strengthening the pleasure to learn STEM and students' self-perceived capability to deal with STEM).
- A coherent and rigorous curriculum that focuses on few fundamental ideas, instead on collections of fragmented concepts and series of disconnected facts, is essential for any successful STEM school initiative.
- Activities must be carried out covering the whole period of primary and secondary school and anchored in the curriculum.
- Masculine stereotypes of STEM careers and STEM professionals should be broken (although this does not mean that STEM subjects should be adjusted to match perceived typical girls' and boys' interests, since this might be ineffective).
- Instead of working on one-off uncoordinated activities, efforts should be devoted towards more long range strategies.
- Better links between industry and main providers or agencies specialising in liaison with schools should be established to provide more strategic, coherent collaboration and to make opportunities more widely available, with better quality control and evaluation.
- The commitment of head teachers is essential for the success of school-industry links (especially in schools without an obvious STEM employer presence in their locality).

- Career orientation needs to be improved (e.g. through professional mentoring schemes and other STEM career-related learning activities, as well as by offering STEM-focused professional development to teacher that emphasize career awareness).
- Industry could play a greater role in supporting teachers CPD (particularly career advisers and guidance teachers) and showing the general public the wide diversity of STEM-related careers.

Finally, based on the topics covered by the reported studies, some particularities were found pointing to certain areas as especially relevant in different countries:

- In the UK, evaluation of the impact or outcomes of existing initiatives (many of which involve “employer engagement” with education).
- In the Netherlands, links between industry and education at higher stages (vocational, college, etc.) and benefits of authentic practices as contexts for teaching and learning.
- In Germany, initiatives specifically addressed to promote STEM among girls as a way of addressing the gender imbalance in STEM.
- In Israel, the social image of scientists and the link with students’ cultural background.
- In Sweden, entrepreneurship and entrepreneurial learning.

These particularities confirm the need to promote cross-country cooperating across Europe in order to take advantage of the strengths and potentialities of each country in the field of promoting STEM careers by means of S-I cooperation.

APPENDIX I – LIST OF ABBREVIATIONS

ACRONYM	MEANING
CPD	**Continuous Professional Development**
S-I	**School-Industry**

APPENDIX II - DETAILS OF THE CALL FOR NATIONAL STEM EXPERTS IN THE AREA OF SCHOOL-INDUSTRY COLLABORATION

Background

The overall aim of the inGenious project is to reinforce the link between school – industry collaboration by coordinating and building upon existing school and industry initiatives in the area of STEM education with the scope of fostering young European's interest in STEM education and careers.

Within this context a call for the nomination of National STEM experts in the area of school-industry collaboration is being launched to identify research studies, STEM education and reports which were developed and publicly available at national level with the scope of promoting school-industry collaboration as a way of fostering students' interest in STEM careers.

Profile

National academic expert with relevant experience and knowledge on the school-industry collaboration in STEM Education who will compile high quality and timely information on the subject matter.

Tasks

The expert will **identify research studies, STEM Education projects and reports** which have been developed in your country and **which involve and/or promote school-industry partnerships** as a way of fostering students' interest on STEM careers. In particular, the goal is to identify:

- Relevant research in the field of STEM related to school-industry initiatives **which has achieved impact to be published at national and international level.**

- Research results about existing national and local initiatives in Europe that have been researched only at national level with **research results disseminated only in the national language at national level.**

APPENDIX III - FIELDS REQUESTED IN THE QUESTIONNAIRE ADDRESSED TO THE STEM EXPERTS

NATIONAL STEM EXPERT DETAILS	1. Name of expert
	2. Country
	3. Select what would you like to report
REPORT DETAILS	1. Title of the report
	2. Name of author/s
	3. Year of publication
	4. Provide the hyperlink of the report (if available)
	5. Provide an abstract of the report (in english)
RESEARCH STUDY DETAILS	1. Title of the study
	2. Name of author/s
	3. Year of publication
	4. Name of national or international journal, issue number and pages (if applicable)
	5. Provide the hyperlink of the research study (if available)
	6. Provide an abstract of the research study and main findings (in english)
PROJECT DETAILS	1. Name of the project

	2. Name of the funding body
	3. Number of partners in the project
	4. List the country / countries involved in the project
	5. Provide the hyperlink of the project (if available)
	6. Provide an abstract on the project (in english)
OTHER DETAILS	1. Title
	2. Author / institution
	3. Year of publication
	4. Provide the hyperlink (if available)
	5. Provide an abstract (in english)

APPENDIX IV - LIST OF PROJECTS/INITIATIVES REPORTED BY THE NATIONAL STEM EXPERTS

Name of the initiative	Funding body/bodies	Countries involved	Hyperlink
Industry in school	Austrian chamber of industry (iv)	Austria	http://www.dieindustrie.at/ausbildung/kooperation-industrie/klassenzimmer/
Schools in the industy	Austrian chamber of industry (iv)	Austria/styria	http://www.erlebniswelt-wirtschaft.at/
Get into technic	Salzburg chamber of industry	Austria/salzburg	http://www.die-salzburger-industrie.at/schulworkshops.49.0.html
Cooperation school-industry	-	Austria	http://www.dieindustrie.at/uploads/2011/03/2013_09_%c3%9cbersicht_kooperation-schule-industrie_low.pdf
Cooperation between school and private enterprises within business & commercial, food processing & technology education	Landwirtschaftliche fachschule pyhra	Austria	www.lfs-pyhra.ac.at
stimula: stimulating science & technology competences through innovative means for	-	Germany romania spain	http://stimula-project.eu/

teaching and learning			http://stimula.files.wordpress.com/2013/09/stimula_book.pdf
Escolab	-	Spain	http://www.escolab.cat/index-e.php?opcio=quees
Engineering by doing	Euss (escola universitària salesiana de sarrià)	Spain	http://www.euss.es/web/portal/ca/continguts/175/engineering-by-doing.htm
Petit (proyecto educativo de tecnología, innovación y trabajo)	Valnalon (ciudad tecnológica del valle del nalón)	Spain	http://www.valnaloneduca.com/petit/

Name of the initiative	Funding body/bodies	Countries involved	Hyperlink
Connecta't a l'enginyeria	-	Spain	http://www.carnetjove.cat/connectat/mostrabecaconvocatoriadetalls!mostraconvocatoriafrombo.action?convocatoriatraspas=779920
Noa & max. Atrapats en electrònia ("noa & max, stuck in electronia")	Fecyt, everis and upf (universitat pompeu fabra)	Spain	http://www.noamaxproject.com/?lang=es
Supporting guidance of primary school pupils on vet through the development of polytechnic education aimed at developing job skills and working with talents	Co-financed by eu through social funds	Slovakia	http://www.siov.sk/narodny-projekt-/24512s
Development of secondary vocational education	-	Slovakia	http://www.siov.sk/o-projekte-bek/24508s
Festival vedy a techniky / science fair of slovakia - festival of science and technology	-	Slovakia	http://www.festivalvedy.sk/
Forscherinnen camp	Bayerisches staatsministerium für wirtschaft, infrastruktur, verkehr und technologie (bavarian ministry for economy, infrastructure, traffic and	Germany: bavaria	http://www.tezba.de/cms/website.php?id=/de/index/aktivitaumlten/maumldche

	technology) bayerische metall- und elektro-arbeitgeberverbände bayme und vbm (bavarian metal and electronical employers' association)		n/forscherinnen-camp.html
Kitec – kinder entdecken technik	Wissensfabrik	Germany	https://www.wissensfabrik-deutschland.de/portal/fep/de/dt.jsp?setcursor=1_443716

Name of the initiative	Funding body/bodies	Countries involved	Hyperlink
Power4school – schüler entdecken energie	Wissensfabrik	Germany	https://www.wissensfabrik-deutschland.de/portal/fep/de/dt.jsp?setcursor=1_517164
Nawi – geht das? / nawi plus	Wissensfabrik	Germany	https://www.wissensfabrik-deutschland.de/portal/fep/de/dt.jsp?setcursor=1_443713
Vom klein-sein zum einstein	Wissensfabrik	Germany	https://www.wissensfabrik-deutschland.de/portal/fep/de/dt.jsp?setcursor=1_453574
Niedersachsen-technikum	Niedersächsisches ministerium (qualifizierungsoffensive niedersachsen)	Germany	http://www.niedersachsen-technikum.de/koordinierungsstelle/aufgaben-und-ziele.html
Mintalente	Vdi - verein deutscher ingeniuere	Germany	http://www.mintrolemodels.de/index.php?id=2250
Mint relation	Initiative neue qualität der arbeit	Germany	www.mintrelation.de
Genius	Daimler	Germany	http://www.genius-community.com/
Girls day	Bundesministerium für bildung und forschung bundesministerium für familie, senioren, frauen und jugend europäischer sozialfonds für	Austria switzerland the netherlands belgium kosovo czech republic spain luxembourg poland	http://www.girls-day.de/

	deutschland europäische union	liechtenstein kirgistan hungary france italy norway estonia japan	
Thyssenkrupp steel europe	Thyssenkrupp	Germany	http://karriere.thyssenkrupp-steel-europe.com/en/career/school-students/kooperation-schulewirtschaft/schulkooperationen.html

Name of the initiative	Funding body/bodies	Countries involved	Hyperlink
Schulewirtschaft	Beauftragte der bundesregierung für migration, flüchtlinge und integration; bertelsmann stiftung; bundesagentur für arbeit; bundesministerium des innern; bundesministerium für wirtschaft und technologie; deutsche kreditbank ag; deutscher sparkassen- und giroverband; mcdonald's; stiftung der deutschen wirtschaft; siemens.	Germany, all federal states	http://www.schulewirtschaft.de/www/schulewirtschaft.nsf/id/en_home
Ada-lovelace-project	-	Germany	http://www.ada-lovelace.com/
Girls' day – mädchen-zukunftstag	-	Germany	http://material.kompetenzz.net/girls-day/veroffentlichungen
Views program	-	Israel	http://www.insidehighered.com/views/2012/09/20/essay-role-research-universities-promoting-stem-education#.ulpczz7weeq.email
Ta'asiyeda industry for advanced education	The manufacturers' association of israel	Israel	http://www.industry.org.il/eng/?categoryid=769
Tov - the technician and matriculation programme (tech-mat)	Department for technology education and vocational training, ort israel, amal vocational schools and manufacturers' association of israel	Israel	http://www.industry.org.il/?categoryid=1485&articleid=1135&sng=1

Cadre for science and technology	Ministry of education	Israel	http://cms.education.gov.il/educationcms/units/madatech/hinucmadatech/projects/atuda/atudalemanhigutmadayit.htm
Atidim	The ministry of education, the jewish agency for israel, leumi bank, private wertheimer foundation	Israel	http://atidim.org/

Name of the initiative	Funding body/bodies	Countries involved	Hyperlink
Experimint	Experimint e.v.	Germany	Http://www.experimint.de/de/ http://www.komm-mach-mint.de/mint-du/projekt-des-monats/experimint
Junior-ingenieur-akademie	Deutsche telekom stiftung	Germany	Http://94.100.251.4/dtag/cms/content/telekom-stiftung/de/410620
Mathe4life	Stiftung rechnen	Germany	Http://stiftungrechnen.de/index.php/projekte/mathe4life
Roberta - lernen mit robotern	Fraunhofer iais	England italy sweden switzerland austria	Http://www.roberta-home.de/de
Nawi aktiv +!	Deutsche post ag	Germany: schleswig-holstein	Http://www.nawi-aktiv.de/ http://www.nawi-aktiv.de/english/
Kieler forschungswerkstatt	Leibniz-institut für die pädagogik der naturwissenschaften und mathematik (ipn); exzellenzcluster "ozean der zukunft" (cau); exzellenzcluster "entzündungsforschung" (cau); sonderforschungsbereich 677 (cau); mathematisch-naturwissenschaftliche fakultät (cau); technische fakultät (cau); ministerium für bildung und wissenschaft schleswig-holstein; stadtwerke kiel; stadt kiel; industrie- und	Germany	Http://www.forschungs-werkstatt.de/

	handelskammer kiel (ihk); lighthouse foundation.		
Evat: entdecken, verstehen, anwenden, transferieren	Metropolregion hamburg	Germany: hamburg, niedersachsen, schleswig-holstein	Http://metropolregion.hamburg.de/leitprojekte/3034116/1-7-evat.html

Name of the initiative	Funding body/bodies	Countries involved	Hyperlink
The net@ cisco project	Cisco and three nongovernmental organizations (ngos): keren hayesod united israel appeal; tapuah, the israeli association for the advancement of the information age; and the jewish agency.	Israel	http://www.jafi.org.il/jewishagency/english/israel/youthfutures/highschool/neta/news/2009 https://www.cisco.com/web/about/ac48/pdf/eu_case_study_net.pdf http://www.youtube.com/watch?v=vlnzqj8vl0q
Movilot latechnion, females leading to the technion, to stem and to industry	The technion, haifa municipality, manufacturer's association of israel, wizo (women's zionist organization), in collaboration with intel, ibm and rafael industries	Israel	http://movilot-latechnion.com/about_u/
Internship program at ort braude college	Ort braude college	Israel	http://www.braude.ac.il/?catid=%7b3418246a-d4f6-4f0c-930c-72f8ba25bb53%7d
Intel in education	Intel	Israel	http://www.intel.com/cd/corporate/education/emea/heb/395465.htm http://www.intel.com/content/www/us/en/corporate-responsibility/intel-in-israel.html?wapkw=israel+education
Miphne –educational	Ministry of economy	Israel	http://www.moital.gov.il/nr/exeres/0c542a56-23ca-4533-8229-

technological centre			d4ec74339907.htm
First (for inspiration and recognition of science and technology)	First usa. Israel usa, industries, ministry of education	Israel, usa	http://www.firstisrael.org.il/

Name of the initiative	Funding body/bodies	Countries involved	Hyperlink
Science is for sharing	Weizmann institute of science	Israel	http://wis-wander.weizmann.ac.il/science-and-society#.unhrmfnibgh
Establish. European science and technology in action: building links with industry, schools and home	-	Ireland; sweden; poland; czech republic; malta; slovakia; estonia; italy; germany; netherlands; cyprus	http://www.establish-fp7.eu/
Euroskills	-	Austria, belgium, bulgaria, croatia, cyprus, estonia, finland, france, germany, hungary, italy, latvia, lithuania, luxemburg, malta, norway, portugal, slovenia, slovakia, spain, switzerland, sweden, netherlands, great britain	http://www.euroskills.org/
Mascil. Mathematics and science for life! Supporting actions on innovation in the classroom: teacher training on inquiry based teaching methods on a large scale in europe	-	Germany, greece, netherlands, england, spain, norway	http://www.mascil-project.eu/

Name of the initiative	Funding body/bodies	Countries involved	Hyperlink
Primas. Promoting inquiry in mathematics and science education across europe		Germany, switzerland, netherlands, uk, spain, slovakia, hungary, cyprus, malta, denmark, romania, norway	http://www.primas-project.eu/
Career day	Jet-net	Netherlands	http://www.jet-net.nl
Dutch technology week	-	Netherlands	http://dutchtechnologyweek.com/
Engineer at school	Kivi niria and jet-net	Netherlands	http://www.ingenieuratschool.nl/
Expedition chemistry	-	Netherlands	http://www.c3.nl/projecten/overzicht-projecten/details/expedition-chemistry
First lego league	-	International	http://www.legoleague.org/
Girlsday	-	Netherlands	http://www.girlsday.nl/girlsday-in-english.html
Lab experience days	-	Netherlands	http://www.labexperience.nl/
Oefenfabriek	-	Netherlands	http://www.oefenfabriek.nl/
Waterfabriek	-	Netherlands	http://waterfabriek.tumblr.com/
Volvo adventure	Volvo group	International	http://www.volvoadventure.org/default.aspx?cookie=test

Virtue school project		Sweden	http://www.science.gu.se/samverkan/skolkontakter/grundskolan/virtue/
Scania summer school	Scania cv ab	Sweden	http://www.scaniahalsocenter.se/personalarrangemang/sommarskola-teknik/
Liseberg and physics, mathematics	Liseberg ab; university of gothenburg; halmstad university	Sweden	http://liseberg.com/en/home/

Name of the initiative	Funding body/bodies	Countries involved	Hyperlink
Problemlösarna	Teknikföretagen	Sweden	http://www.problemlosarna.nu/
Teknikspanarna, “the technology watchers”	Teknikföretagen	Sweden	http://www.teknikforetagen.se/hem/vi-arbetar-med/kompetensforsorjning/aktiviteter--projekt/teknikspanarna/
Stemnet - science, technology, engineering and mathematics network	Uk government department for business innovation and skills; uk government department for education; the scottish government; the gatsby charitable foundation.	England scotland wales	www.stemnet.org.uk
Bloodhound ssc	A wide range of sponsors are involved, including swansea university, the engineering and physical sciences research council, serco, university of west of england, stp, ris, rolls royce, goodridge fluid transfer systems, institution of mechanical engineers, cisco, the british army, the royal air force, northern cape, mtn and cosworth. Other sponsors have been involved in earlier stages, and it is very likely that further sponsors will become engaged as the project develops	All uk south africa a growing number of countries around the world have schools registering with the project	www.bloodhoundssc.com
Project enthuse	Co-funding by partners department for education, wellcome trust, bp, astrazeneca, astrazeneca science teaching trust, electric foundation, bae systems, glaxosmithkline, roll	England, scotland wales, northern ireland also open to republic of ireland	https://www.sciencelearningcentres.org.uk/about/partners/project-enthuse/

	royce, vodaphone, vodaphone group foundation		

Name of the initiative	Funding body/bodies	Countries involved	Hyperlink
Bp schools link	Bp sponsored	Uk	-
The smallpeice trust	Smallpeice - indpendent charitable trust established in 1966 by dr cosby smallpeice (engineer)	Uk	http://www.smallpeicetrust.org.uk/
Young engineers	-	England, wales and scotland	http://www.youngeng.org/home.asp
Tomorrow's engineers	-	Uk	http://www.tomorrowsengineers.org.uk/home.cfm
Career academies uk	-	Uk	http://www.careeracademies.org.uk/
The big bang	Engineering uk in partnership with the british science association, the royal academy of engineering and young engineers	Uk	www.thebigbangfair.co.uk
Nuffield research placements	The nuffield foundation	Uk	www.nuffieldfoundation.org/nuffield-research-placements

REFERENCES

Akkerman, S. F., and Bakker, A. (2012). Crossing boundaries between school and work during apprenticeships. *Vocations and Learning, 5*(2), 153-173.

Akkerman, S.F., and Bakker, A. (2011). Boundary Crossing and Boundary Objects. *Review of Educational Research, 81*(2), 132-169.

Archer, L. (2013). *Interim Research Summary, ASPIRES Project*. London.

Bakker, A., Groenveld, D.J.G., Wijers, M., Akkerman, S. F., and Gravemeijer, K.P.E. (2012). Proportional reasoning in the laboratory: An intervention study in vocational education. *Educational Studies in Mathematics.* Retreived (on 20th January, 2014) from:http://link.springer.com/article/10.1007%2Fs10649-012-9393-y

Bakker, A., Van Mierlo, X., and Akkerman, S. F. (2012). Learning to integrate statistical and work-related reasoning. *Conference proceedings ICME 2012.*

Bakker, A., Hoyles, C., Kent, P., and Noss, R. (2005). Designing Learning Opportunities for Techno-Mathematical Literacies in Financial Workplaces: A status report. Information on the project available and retreived (on 20th January, 2014) from: http://www.lkl.ac.uk/research/technomaths/

Bayer Corporation (2010). Planting the Seeds for a Diverse U.S. STEM Pipeline: A Compendium of Best Practice K-12 STEM Education Programs. Retreived (obn 26th February, 2014) from:http://www.bayerus.com/msms/web_docs/compendium.pdf

Berkhout, E., Sattinger, M., Theeuwes, J., & Volkerink, M. (2012). *Into the gap*. Amsterdam.

Bildungswerk der Bayerischen Wirtshaft e.V (2011). *“Forcherinnen-Camps”. Eine Woche Ingenieurin sein.* German version (retreived on 31st January, 2014) from: http://www.schulewirtschaft.de/www/schulewirtschaft.nsf/res/91FC32C6BE8B2F37C12579B100484938/$file/forscherinnenCamp.pdf

Booy, C., Jansen, N., Joukes, G. and Van Schaik, E. (2012). Trend analysis gender in higher STEM education. Retreived (on 13th January, 2014) from: http://www.vhto.nl/fileadmin/user_upload/images/publicaties/LR_VHTO_GENDER_ENGELS_TOTAAL.pdf

Brandford, J. D., Brown, A. L., and Cocking, R. R. (2000). *How People Learn: Brain, Mind, Experience, and School*. Washington, D.C.: National Academy Press.

Business Europe (2011). Plugging the Skills Gap – The clock is ticking. Retreived (on 26th February, 2014) from:http://www.businesseurope.eu/Content/Default.asp?pageid=568&docid=28659

Bütikofer, R. (2013). Draft Report on reindustrialising Europe to promote competitiveness and sustainability. European Parliament 2009-2014. Retreived (on 26th February, 2014) from:http://www.europarl.europa.eu/sides/getDoc.do?type=COMPARL&reference=PE-510.843&format=PDF&language=EN&secondRef=01

Collins, J. (2013). *Evaluation of "RAF WISE" Work Experience Programmes, RAF Cosford 2009-2012.* Retreived (on 26th February, 2014) from: http://www.wiset.org.uk/index.php?mact=News,cntnt01,detail,0&cntnt01articleid=573&cntnt01returnid=26

Department for Employment and Learning (2011). *Success Through STEM: STEM Strategy – In response to the "Report of the STEM Review"*. Retreived (on 26th February, 2014) from: http://www.delni.gov.uk/2857p_stem_booklet_v5.pdf

Department for Employment and Learning (2012). *Success Through STEM: One year on.* Retreived (on 26th February, 2014) from: http://www.delni.gov.uk/success-through-stem-one-year-on.pdf

DG Enterprise and Industry (2013). *Enterpreneurship Education: A Guide for Educators*. European Commission. Retreived (on 24th January, 2014) from:http://ec.europa.eu/enterprise/policies/sme/promoting-entrepreneurship/files/education/entredu-manual-fv_en.pdf

Dierdrop, A., Bakker, A., Eijkelhof, H.M.C., and Van Maanen, J.A. (2011). Authentic practices as contexts for learning to draw inferences beyond correlated data. Mathematical Thinking and Learning, 13(1&2), 132 – 151.

European Round Table of Industrialists (2009). Mathematics, Science & Technology Education Report. The Case for a European Coordinating Body. Retrieved (on 26th February, 2014) from: http://www.ert.eu/sites/default/files/MST%20Report%20FINAL.pdf

Education and Training Inspectorate (2010). Evaluation of the progress of the Science, Technology, Engineering and Mathematics (STEM) Careers Education Information, Advice and Guidance Programme (CEIAG) (Northern Ireland). Retreived (on 26th February, 2014) from: http://www.etini.gov.uk/index/surveys-evaluations/surveys-evaluations-post-primary/surveys-evaluations-post-primary-2010/an-evaluation-of-the-progress-of-the-science-technology-engineering-and-mathematics-stem-careers-education-information-advice-and-guidance-ceiag-programme-post-primary.htm

Fraser, E. (2013). 100 CEO Leaders in STEM. A publication by STEMconnector®. Retreived (on 26th February, 2014) from:http://www.stemconnector.org/sites/default/files/100-CEO-Leaders-in-STEM-web.pdf

E-nnovate Israel (2013). Advancement of innovation and economic growth in Israel through media and communication technology. Hebrew version retrieved (on 3rd February, 2014) from http://ennovate.withgoogle.com/files/E-nnovate-Israel-Hebrew.pdf

EU Skills Panorama (2012) STEM Skills Analytical Highlight, prepared by ICF GHK for the European Commission.

Eurydice (2011a). Mathematics Education in Europe: Common challenges and national policies. Retreived (on 26th February, 2014) from: http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/132EN.pdf

Eurydice (2011b). Science Education in Europe: National Practices, Policies, and Research. Retreived (on 26th February, 2014) from: http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/133EN.pdf

Finegold, P., Stagg, P. and Hutchinson, J. (2011). Good Timing: Implementing STEM careers strategy in secondary schools. Retreived (on 26th February, 2014) from: http://www.nationalstemcentre.org.uk/res/documents/page/Good_Timing_report_November2011.pdf

Hachmon, O. and Eisenberg, E. (2010). Education & Business: Israel. ETF. Retreived (on 21st January, 2014) from: http://www.etf.europa.eu/webatt.nsf/0/718E662153E2CF8BC1257895004C4E19/$file/Education%20and%20Business%20-%20Israel_EN.pdf

Hanover Research (2011). K-12 STEM Education Overview. Retreived (on 26th February, 2014) from: http://www.hanoverresearch.com/wp-content/uploads/2011/12/K-12-STEM-Education-Overview-Membership.pdf

Hardisty, H., and Cunningham, S. (2013). Changing the pace: CBI/Pearson education and skills survey 2013.

Harland, J., Straw, S., Stevens, E. and Dawson, A. (2012). Exploring the engagement of STEM SMEs with education: key findings research summary. NFER. Retreived (on 21st January, 2014) from http://www.nfer.ac.uk/publications/SMES01

Hofstein, A. and Lunetta, V.N. (2003). The Laboratory in Science Education: Foundations for the Twenty-First Century. Retreived (on 20th January, 2014) from: http://gpquae.iqm.unicamp.br/gtexperimentacao.pdf

Holman, J. and Finegold, P. (2010). STEM Careers Review Report to the Gatsby Charitable Foundation. Retreived (on 26th February, 2014) from: http://www.gatsby.org.uk/~/media/Files/Education/8%20John%20Holman%20review%20of%20careers%20Nov%202010.ashx

Hoyles, C., Noss, R., Kent, P., and Bakker, A. (2010). Improving mathematics at work: The need for techno-mathematical literacies. (no link available).

Hutchinson, J. (2013). School Organisation and STEM Career-related learning. University of Derby & National STEM Centre. Retreived (on 21st January, 2014) from: http://derby.openrepository.com/derby/handle/10545/303288

Iredale, N. (1999). Work-related education in primary schools: a study of industry’s attitudes and teacher motivation. Durhan University. Retreived (on 26th February, 2014) from: http://etheses.dur.ac.uk/1226

Jaansalu, M.L. (2013). Students evaluations of physics science show performance by TÜ Teadusbuss and of learning physics and natural sciences. Retrieved (on 13th January, 2014) from http://www.tandfonline.com/doi/abs/10.1080/09500690802449375#.UtP-BvsfmxV

Kärkkäinen, K. and S. Vincent-Lancrin (2013), “Sparking Innovation in STEM Education with Technology and Collaboration: A Case Study of the HP Catalyst Initiative”, OECD Education Working Papers, No. 91, OECD Publishing. Retreived (on 28th January) from: http://dx.doi.org/10.1787/5k480sj9k442-en

Kearney, C., Wastiau, P., Gras-Velázquez, A., Grečnerová, B. and Baptista, R. (2011). Efforts to Increase Students' Interest in Pursuing Science, Technology, Engineering and Mathematics Studies and Careers: National Measures taken by 21 of European Schoolnet's Member Countries. Retreived (on 27th January, 2014) from: http://spice.eun.org/c/document_library/get_file?p_l_id=16292&folderId=16435&name=DLFE-9323.pdf

Kerr, W. H. (2013). Proposal for an Exemplary Business-Education Collaboration Model – A White Paper prepared for the Norwin Board of Education. Retreived (on 26th February, 2014) from: http://www.norwinsd.org/STEMwhitePaper

Kisner, M. J., Mazza, M. J. and Liggett, D. R. (1997). Building Partnerships. New Directions for Community Colleges, 1997(97), 23-28.

Koren, P. and Bar, V. (2009). Pupils' image of "the Scientist" among two communities in Israel: A comparative study. International Journal of Science Education, 31(18) 2485 – 2509.

Kudenko, I. and Gras-Velazquez, A. (2013). The future of European STEM workforce: What do secondary school pupils of Europe think about STEM industry and careers? Oral presentation at ESERA 2013, Cyprus.

Mann, A., and Oldknow, A. (2012). School-industry STEM links in the UK: A report commissioned by Futurelab. Retreived (on 21st January, 2014) from: http://www.nfer.ac.uk/publications/FUTL10

Marco, S. and Garriga, J. (2012). Factors influencing students' decision-making process in choosing STEM studies. Catalan version retreived (on 20th January, 2014) from: http://www.everis.com/catalonia/WCLibraryRepository/Factors%20influents%20eleccio%20estudis%20CTM.PDF

Marginson, S., Tytler, R., Freeman, B. and Roberts, K. (2013). STEM: Country comparisons. Report for the Australian Council of Learned Academies, www.acola.org.au. Retreived (on 26th February, 2014) from:http://www.acolasecretariat.org.au/ACOLA/PDF/SAF02Consultants/SAF02_STEM_%20FINAL.pdf

Mazereeuw, M. and Boersma, K. (2010). Connecting school and work placement: towards a learning and supervising strategy for learning about animal reproduction in Agricultural Education. Paper presented at the ECER VETNET Conference, Berlin. Retreived (on 21st January, 2014) from: http://www.fisme.science.uu.nl/publicaties/literatuur/2010_mazereeuw_ecer_vetnet.pdf

Meiesaar, M. (2010). Scientists and engineers in the social representation among young people. Estonian version retrieved (on 20th January, 2014) from: http://dspace.utlib.ee/dspace/bitstream/handle/10062/15361/Meiesaar_Margit.PDF?sequence=1

Meijer, M. (2011). Macro-meso-micro thinking with structure-property relations for chemistry. An explorative design-based study. Retrieved (on 20th January, 2014) from http://www.fisme.science.uu.nl/toepassingen/20065/

Moolenbroek, J.van (2012). Be aware of behaviour. Learning and technical behavioural biology in secondary education. Abstract and access to the document retreived (on 20th January, 2014) from: http://dspace.library.uu.nl/handle/1874/241933

NSLC (2013). The Future of STEM Education – a National Science Learning Centre White Paper. Retreived (on 26th February, 2014) from:https://www.sciencelearningcentres.org.uk/impact-and-research/research/future-of-stem/

OECD (2008). Encouraging Student Interest in Science and Technology Studies. Retrieved (on 20th January, 2014) from: http://www.oecd.org/sti/sci-tech/encouragingstudentinterestinscienceandtechnologystudies.htm

OPM. (2004). Taking a Leading Role (pp. 1–27).

Osborne, J., and Dillon, J. (2010). Good practice in science teaching: What research has to say (Second). Open University Press.

Osborne, J. and Dillon, J. (2008). Science Education in Europe: Critical Reflections. London: King's College London. Retreived (on 26th February, 2014) from: http://www.nuffieldfoundation.org/sites/default/files/Sci_Ed_in_Europe_Report_Final.pdf

Prins, G.T. (2010). Teaching and learning of modelling in chemistry education. Authentic practices as contexts for learning (no link available).

Quaiser-Pohl, C., Endenpohls-Ulpe, M., Rasic, R., Gnosa, T. and Sander, E. (2012). Mentoring beim Übergang in die berufliche Ausbildung am Beispiel des Ada-Lovelace-Projeks. Diskurs Kindheits- und Jugendforschung, 7, 161-172. German version retreived (on 3rd February, 2014) from http://budrich-journals.de/index.php/diskurs/article/view/7113

Rocard, M. (2007). Science Education Now: A Renewed Pedagogy for the Future of Europe. Retreived (on 26th February, 2014) from: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf

Sagar, H. (2013). Teacher Change in Relation to Professional Development in Enterpreneurial Learning. Faculty of Science at University of Gothenburg (Thesis). Retreived (on 23rd January, 2014) from: http://hdl.handle.net/2077/34375

Sagar, H. and Mehli, H. (2013). Authentic and enterpreneurial teaching practice in science and technology – variation and diversity in outcomes from professional development courses for teachers. NorDiNa, 9(2), 171 – 186. Retreived (on 23rd January, 2014) from: https://www.journals.uio.no/index.php/nordina/article/view/555

Sagar, H., Pendrill, A.M. and Wallin, A. (2012). Teachers' perceived requirements for collaborating with the surrounding world. NorDiNa, 8(3), 227 – 243. Retreived (on 23rd January, 2014) from: https://www.journals.uio.no/index.php/nordina/article/view/530

Savickas, M. L., Nota, L., Rossier, J., Dauwalder, J.-P., Duarte, M. E., Guichard, J., Soresi, S., et al. (2009). Life designing: A paradigm for career construction in the 21st century. Journal of Vocational Behavior, 75(3), 239–250. doi:10.1016/j.jvb.2009.04.004

Schweingruber, Quinn, Keller and Pearson (2013). A Framework for K-12 Science Education: Looking Toward the Future of Science Education. Spring Issue of The Bridge on STEM Education: Progress and Prospects. The National Research Council USA. Retreived (on 26th February) from: http://www.nae.edu/Publications/Bridge/69735/69747.aspx

Scottish Science Advisory Council (2011). Science Education: Enhancing Support for Schools Through Collaboration. Retreived (on 26th February, 2014) from: http://www.scottishscience.org.uk/sites/default/files/article-attachments/SSAC%20Science%20Education%20Report_0.pdf

SEEAG (2012). Supporting Scotland's STEM Education and Culture. Second Report. Retreived (on 26th February, 2014) from:http://www.scotland.gov.uk/Publications/2012/02/4589/0

Sinnes, A.T. and Løken, M. (2012). Gendered education in a gendered world: looking beyond cosmetic solutions to the gender gap in science. Cult Stud of Sci Educ. DOI 10.1007/s11422-012-9433-z.

Stoeger, H., Duan, X., Schirner, S., Greindl, T., and Ziegler, A. (2013). The effectiveness of a one-year online mentoring program for girls in STEM. Computers & Education, 69, 408-418. DOI 10.1016/j.compedu.2013.07.032

Stevens, E., Everett, H., MacLeod, S. and Straw, S. (2013). Tomorrow's Engineers careers materials research 2012/13. Slough: NFER.

Straw, S. and Dawson, A. (2012). Bloodhound education programme: follow-up audit of activities. Slough: NFER. Retreived (on 26th February, 2014) from: http://www.nfer.ac.uk/publications/BLDY01/BLDY01_home.cfm?publicationID=669&title=%20Bloodhound%20education%20programme

Straw, S., Hart, R. and Harland, J. (2011). An evaluation of the impact of STEMNET's services on pupils and teachers. Slough: NFER.

Van der Sanden, J., and Teurlings, C. (2003). Developing competence during practice periods: the learner's perspective. Retreived (on 26th February, 2014) from: http://hdl.voced.edu.au/10707/143068

Watters, J. J. and Diezmann, C. M. (2013). Community Partnerships for Fostering Student Interest and Engagement in STEM. Journal of STEM Education, 14(2), 47-55.

Westra, R.H.V. (2008). Learning and teaching ecosystem behaviour in secondary education : Systems thinking and modelling in authentic practices. Abstract and access to the document retreived (on 20th January, 2014) from:http://igitur-archive.library.uu.nl/dissertations/2008-0220-200526/UUindex.html

Yemini, M. and Haddad, J. (2012). Engineer-Entrepreneur: Combining Technical Knowledge with Enterpreneurship Education. The Israeli Case Study. Int. J. Engng Ed. 26(5) 1200 – 1229.