IST – 035266

WWW.BRIGHTER.EU

World Wide Welfare: high-BRIGHTness semiconductor lasers for gEneric Use

IP - Integrated Project
IST - Information Society Technology

Milestone MS 9.3.4

Report on approaches to popularisation targeted at 12-16 years olds

Organisation name of lead contractor for this deliverable:
University of Nottingham

Actual submission date: M42
Due date of deliverable: M42

Start date of project: 01/10/06 *Duration 42 months*

Revision: 1

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
	Dissemination level	
PU	*Public*	*X*
PP	*Restricted to other programme participants (including the Commission Services)*	
RE	*Restricted to a group specified by the consortium (including the Commission Services)*	
CO	*Confidential, only for members of the consortium (including the Commission Services)*	

Authors:

Dr. Steve Bull (e-mail: steve.bull@nottingham.ac.uk)
Prof. Eric Larkins (e-mail: eric.larkins@nottingham.ac.uk)
Department of Electrical and Electronic Engineering
University of Nottingham
University Park
Nottingham, NG7 2RD
UNITED KINGDOM

Executive Summary

The purpose of this report is to discuss effective approaches to communicating the excitement of science and engineering to young people and girls, inspiring them to pursue careers in science, engineering, technology and mathematics (STEM). The popularisation of science among these groups is critically important, since they will be responsible for developing and sustaining tomorrow's technology - with all of its impact on the economy and society.

This report begins by considering a number of relevant questions:

- What are Europe's perceived needs for STEM graduates in the future?
- What are the current trends in the number of STEM graduates in Europe?
- How can the perception and popularisation of STEM subjects be improved?
- What is being done to encourage 12-16 year olds to pursue STEM subjects?

Finally, the report considers ways to facilitate the popularisation of science and technology amongst young people and girls by European research projects.

What are Europe's perceived needs for STEM graduates in the future?

Industry expects a strongly increasing demand for high calibre STEM graduates. This will be fuelled by an increase in the number of STEM graduates in the workforce, the replacement of retiring staff in an aging population and the need to meet the challenges of globalisation. Globalisation is a major challenge facing European industry and will continue to have a major impact upon both the supply and demand sides of the economy. The rapid growth in outsourcing manufacturing to countries with lower labour costs poses a real challenge which will force European engineering in all areas to concentrate on higher value-added activities.

The overall conclusion is that action is needed to address the shortage of high-calibre engineers entering industry – otherwise, the shortage of quality graduates will have serious repercussions for productivity and creativity. Certain disciplines are perceived to be of particular importance. There are already shortages of graduate recruits in Electrical and Electronic Engineering and Systems Engineering. Information and Communications Technology and Materials were also identified by companies as key areas for increased graduate recruitment to support future growth. Public policy makers are also listening to industry's call for more STEM graduates.

What are the current trends in the number of STEM graduates in Europe?

Despite small differences across Europe, the overall trend seems to be that the numbers of STEM graduates is roughly constant – even though there are increasing numbers of students entering higher education. This means that the percentage of young people choosing STEM careers is in decline. Furthermore, the under-representation of women remains a strong concern across Europe. These trends should be taken in the context of industry's demand for more STEM graduates and in the context of increasing globalisation. European economies must now compete with those of rapidly developing countries, such as the BRIC nations (Brazil, Russia, India and China), who are producing record numbers of graduate engineers.

How can the perception and popularisation of STEM subjects be improved?

Prof. Julia E. King, chair of the Royal Academy of Engineering's *Educating Engineers for the 21st Century Working Party*, said "at this time when our need for engineering talent is huge, and when our young people are increasingly interested in how they can help to save the planet, we are failing to persuade them that engineering careers are exciting, well-paid and

worthwhile." To reach out effectively to these groups, we must begin by looking at the public's perception of engineering. We must understand what stimulates their interest in science and technology and what motivates them to pursue STEM subjects in school.

The public has a limited awareness and understanding of engineering and engineers. Initial associations saw engineers as people who built or fixed things rather than designing or creating them. Younger people were found to have a much more limited understanding of engineering than other groups. Positive attitudes were related to the belief that engineers and scientists provided many of the things people rely upon. Increased awareness/understanding of engineering impacted positively on people's interest in engineering. There is a clear need for increased public engagement and a larger media presence – particularly in television.

The success of outreach activities among young people is influenced by: the 'wow factor'; the simplicity of the idea; the contribution to social responsibility; the potential for large scale change; and the relevance to their own interests. Women were more motivated to pursue scientific and technical subjects perceived as creative and contributing to society.

What is being done to encourage 12-16 year olds to pursue STEM subjects?

There is a wide range of outreach actions, which can be broadly classified as: web based; competitions and awards; clubs; fairs and festivals; direct outreach actions, and curriculum support. There are also specific actions targeting women. Nevertheless, there are still some points for real concern:

1. There is evidence of serious fragmentation of these activities – both within a single country and across Europe.
2. Most websites and materials are only available in a single language – usually English.
3. There are too few visible role models in science and engineering.
4. There is a lack of quantity and breadth of TV programs which target young people and portray modern science and engineering as creative and exciting.

Finally, the report considers a few ways in which the EC and EC-funded research projects could help to address these four points:

- It is important to provide the public (and the national media) with native language materials. Key documents targeting the popularisation of results (e.g. press releases, etc.) could be translated into the languages represented within a Consortium.
- The EC should do more to publicly celebrate innovation – perhaps something like the German Future Prize (Deutsche Zukunftspreis) to recognise projects of high scientific value, with concrete applications that are mature for commercial markets.
- EC-funded projects could be encouraged to produce public exhibits for display in public places (e.g. airports, major train stations, etc.) where they will be encountered by tens of thousands of ordinary people.
- The EC could fund a team (or project) to produce films to popularise the results of successful EC-funded research projects. This should involve filmmakers, TV presenters and experts in pedagogy and sociology to ensure the necessary skills are available at a high professional level. The team (and the EC) could use their contacts to ensure that the films were distributed and shown widely.

1. Introduction

This report was inspired by our experience with dissemination, popularisation and training in the BRIGHT and BRIGHTer integrated projects funded by the European Commission (EC). These projects effectively engaged the scientific and technical communities through a number of channels, including scientific publications, conference presentations, e-Newsletters (with significant technical content) and the project website. Technical training activities were also carried out both within the Consortium (e.g. training exchange visits between partners) and with the wider scientific community (e.g. tutorials, workshops on toxicology and biophotonics and e-Newsletter articles). Finally, the project sought to engage the wider public, including public policy makers, through various means (e.g. a press release in multiple languages, a video clip about the project and various articles in the popular press).

The high level of sustained effort from the Consortium across a wide range of dissemination, popularisation and training activities, including a short film and 17 multi-media tutorials [1], provided useful insights into which activities and approaches were successful. These are described in detail in other project documents [1], which provide a good basis for sharing best practice with other projects. The purpose of this report is to discuss an area where more effective approaches to popularisation are needed – communicating the excitement of science and engineering to young people and girls to inspire a greater number of them to pursue careers in science, engineering, technology and mathematics (STEM). The popularisation of science among these groups is particularly important, since they will be responsible for developing and sustaining tomorrow’s technology. Whether at a university, a research institute or in industry, the BRIGHTer partners all felt that it was important to do more to reach out to these groups.

Young people are more difficult to reach for a number of reasons. Firstly, the message needs to be pitched in a different way – science and technology need to be presented as exciting (“wow” factor) and the ideas need to be simple. Secondly, the message has to be presented and delivered using media widely accessed by this group (e.g. films on TV, videos on YouTube, etc.). Unfortunately, most researchers lack experience both in communicating science to teenagers and in producing films or video clips. Finally, there is the problem of marketing and distribution. For example, in order to market a science TV program, good contacts with television stations are needed along with a critical mass of material (i.e. individual topics/films).

This report begins by considering a number of relevant questions:

- What are Europe’s perceived needs for STEM graduates in the future?
- What are the current trends in the number of STEM graduates in Europe?
- How can the perception and popularisation of STEM subjects be improved?
- What is being done to encourage 12-16 year olds to pursue STEM subjects?

These questions are considered within the context of materials and studies obtained by partners within the consortium. Within the limited context of this project (and especially this report), it is not possible to provide a comprehensive discussion of these questions. The purpose of including these questions is to: a) put the challenge into context; b) provide an impression of what is being done; and c) to bring in useful information and ideas. Finally, the report considers ways to facilitate the popularisation of science and technology amongst young people and girls by European research projects.

2. What are Europe's perceived needs for STEM graduates in the future?

In this section, we consider the reasons why Europe is expected to need more high calibre STEM graduates in the future, drawing our information from a number or recent high-profile studies. Although these studies were commissioned and performed in the UK, the observations and conclusions seem likely to remain broadly valid across the European community. We begin by considering the social and economic role of engineers and scientists. Globalization is one of the major challenges faced by European industry and the need to respond to this challenge is affecting the role of engineers and scientists. Next, the expectation of a shortage in STEM graduates is considered, along with an indication of the disciplines most severely affected. Finally, we consider the position taken by policy makers in response to these studies.

Engineers and scientists are expected to play a key role in meeting the economic and social challenges we currently face. "Engineers and scientists are the people who will slow down global warming, deal with its current and future effects and develop carbon-neutral fuels to ensure the continuation of our planet. They will develop new treatments for previously life-threatening or debilitating diseases, ways of increasing food production and ways of supplying developing nations with clean, safe drinking water [2]." Although the role of science and engineering in addressing social issues seems obvious, Section 4 will show that there is a need to improve this perception amongst the general public.

Globalisation is a major challenge facing European industry and will continue to have a major impact upon both the supply and demand sides of the economy. The Henley report [3] concludes that "the rapid growth in placing work offshore poses a real challenge that will force UK engineering in all areas to concentrate on higher value-added activities. As a result, there will be a premium on innovation and creativity to respond to the challenges of this turbulent environment." The industrialists consulted in this report emphasized the need for "innovative and creative people who can deal with the complex and changing environment that was expected to characterise the industry of the future, and provide the leadership the industry would need. … The emphasis on innovation and creativity can be linked both to the challenge of competition from overseas, and the desire to use human capital as a hedge against an unpredictable future." This conclusion is likely to be true for all of the developed economies in Europe.

Engineering firms in the UK expect to the numbers of graduates in their workforce to increase over the next decade [3]. At the same time, it is widely predicted that there will be an increasing shortage of graduate engineers [3-6]. In *Educating Engineers for the 21st Century* [4], the Royal Academy of Engineering reported that "industry expects that the supply of high calibre engineering graduates will steadily diminish over the next ten years with serious and direct repercussions for productivity, creativity and hence profitability. … The objective must be a step change in the number of students entering engineering degree courses without any compromise to the quality of qualification they eventually receive." Even studies published as recently as February 2010 (i.e. subsequent to the crisis in the global financial markets) predict a shortage in STEM graduates. "Although applicant numbers in engineering and technology are up 16% since 2007 and net job losses in industry are expected over the next few years, the number of engineering graduates is unlikely to be sufficient, partly due to the need to replace engineers who are retiring [6]."

The overall conclusion is that action is needed to address the shortage of high-calibre engineers entering industry – otherwise, the shortage of quality graduates will have serious repercussions for productivity and creativity. Certain disciplines are perceived to be of particular importance. For example, shortages of graduate recruits were already reported in Electrical and Electronic Engineering and Systems Engineering. Furthermore, companies “identified Information and Communications Technology and Materials as key areas for increased graduate recruitment to support future growth [4].” The Henley report also concluded that “engineering graduates in many of the disciplines included in the survey will be in somewhat greater demand. Systems engineers, electrical/electronic engineers would appear to be likely to see such an increase, followed (perhaps somewhat surprisingly) by production/manufacturing engineers and computer sciences/software engineers. [3]”

Public policy makers are also responding to industry’s call for more STEM graduates. The UK Government’s *Science and Innovation Investment Framework 2004-14* [7] highlighted the importance of STEM skills to future prosperity: “To support the UK’s ambition to move to a higher level of research and development (R&D) intensity, it is crucial to ensure that the UK has the right stock and flow of skilled scientists, technologists, engineers and mathematicians, as well as technicians and other R&D support staff, generated from within the UK and attracted from abroad. A highly skilled, diverse workforce will contribute to **business productivity and innovation**, enabling UK businesses to exploit fully new technologies and scientific discoveries, achieve world-class standards and compete globally.”

3. What are the current trends in the number of STEM graduates in Europe?

The preceding section revealed a strong industry perception that there would be an increasing demand for high calibre STEM graduates. This demand is being fuelled by an overall increase in the number of STEM graduates in the workforce, the need to replace retiring staff in an aging population and to meet the challenges of globalization. In this section, we look briefly at current trends in STEM graduates to see how effectively this increased demand is being met. In order to identify current trends in each of the countries represented within the BRIGHTer project, the partners were asked to locate information about how the numbers of STEM graduates produced in their country had changed over recent years. As the overall percentage of women pursuing STEM careers is quite low, the partners were also asked to find information about trends in the relative numbers of women STEM graduates.

In the United Kingdom, the Royal Academy of Engineering reports that “the basic output of engineers is effectively stagnating. Between 1994-2004 the number of students embarking on engineering degrees in UK universities remained static at 24,500 each year even though total university admissions rose by 40% over the same period [4].” This problem is exacerbated by the fact that women still only represent 14% of engineering undergraduates and that some socio-economic groups are also under-represented. In 2008, the Department for Innovation, Universities and Skills (DIUS) published the report *A Vision for Science and Society*, which observed that the “science workforce is not yet truly representative, with a significant gender imbalance in many areas, as well as poor representation of some ethnic minorities [8].” Furthermore, only about 70% of the engineering graduates in the UK actually went into an engineering and technology occupation.

Finally, the supply of STEM graduates depends on the earlier supply of applicants with the appropriate qualifications and on how many of them continue to study STEM courses in higher education. The Russell Group of universities has expressed its concerned over the dramatic long-term fall in the take-up of many STEM subjects at school: “The number of students taking ‘traditional’ subjects, particularly in physical sciences and maths, has become worryingly low, despite recent modest increases:

- **From 1989-2004, maths entries fell by 40%.** Following curriculum changes in 2006-7, the number of candidates taking maths has started to increase.
- In 2008, the percentage of pupils taking maths (7.5%), chemistry (3.5%), biology (2.7%) and physics (2.3%) increased. However, these numbers are **still significantly below their previous levels, after almost two decades of decline**. [5]"

In Denmark, although the numbers of high school students has increased slightly over recent years (Fig. 1), the numbers of men and women choosing to pursue STEM subjects in higher education has declined (Fig. 2). On the positive side, however, there has been a slow, but steady increase in the numbers of students (particularly women) pursuing postgraduate degrees in STEM subjects (Figs. 2 and 3).

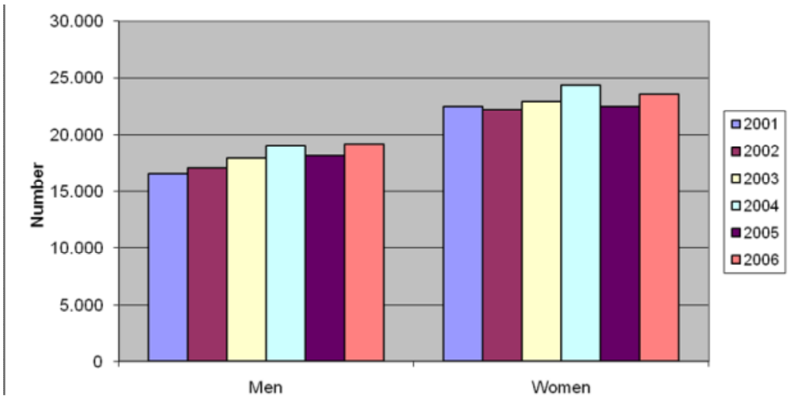

Figure 1: *Intake of students at high school level in Denmark between 2001 and 2006.*

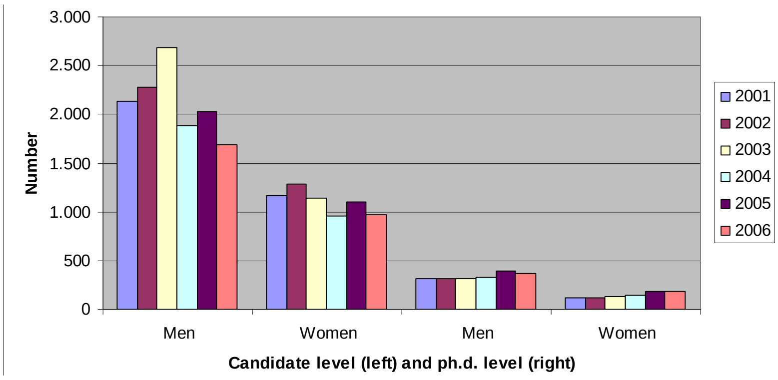

Figure 2: *Intake of students in STEM subjects in Denmark between 2001 and 2006 at undergraduate (left) and postgraduate (right) level.*

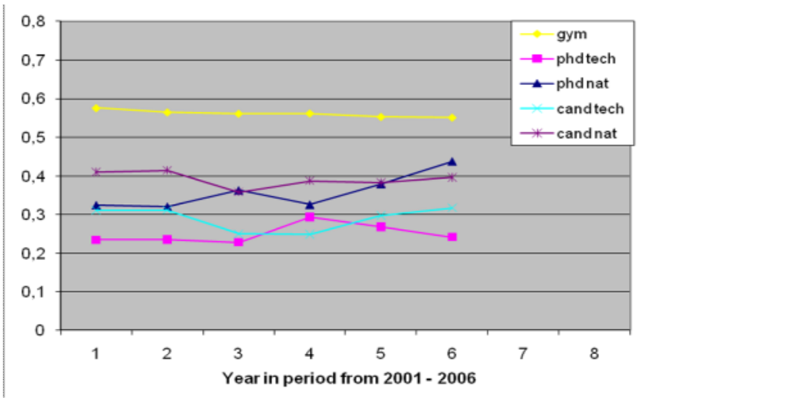

Figure 3: *Relative changes in university student intake of female students in technology subjects and the natural sciences at undergraduate and PhD level.*

In France, figures from the French Ministry of Education [9] show that the total number of students (undergraduate and postgraduate level) involved in STEM subjects (also including medicine) has remained steady at about 31% over the period 2000 – 2008. Without the inclusion of medicine, this number was about 23% in 2008, which is a slight reduction in the level in 2000 (~24%). However, despite this modest decrease there has been a major shift in the way in which students in France are pursuing science and engineering educations. Over the past decade, the number of students studying science and technology at universities has decreased by ~10%. However, this has been balanced with a matching increase in the number of students in engineering schools (Grandes Ecoles) and technological institutes. In 2008, the percentage of female students in the fundamental sciences stood at 29% (undergraduate level), 26% (masters level) and 28% (PhD level).

In Poland, anecdotal evidence (e.g. the closure of some physics departments in Poland) suggests that the numbers of science and engineering students are declining and have been doing so for a number of years. This is confirmed for the 2007/08 and 2008/09 periods by the data in Table 1. Although the number of STEM students fell, the percentage of students studying STEM subjects out of the whole student population rose by 1% from 2007/08 to 2008/09. Just under a quarter of all STEM subject students are female, compared to a value of 57% for all students. However, there are marked differences in the female student populations for different subject areas (see Table 1), with ~60% of maths and science students being female in 2008/09. This is in contrast to <20% of students studying engineering being female.

Subject Area	**HE Students**		**% female in 2008/09**
	2007/08	**2008/09**	
Physical sciences	30,800	29,100	59.0%
Mathematics & statistics	15,600	16,800	61.0%
Computing	95,200	87,800	9.7%
Engineering & engineering trades	132,600	13,2000	18.2%
Science / engineering totals	**274,200**	**265,700**	**22.6%**
Totals for all subjects	**1,937,400**	**1,927,800**	**57.0%**

Table 1: *Science and engineering students in higher education in Poland [10]*

In Switzerland, although total student numbers have been steadily rising, the number of students in the technical sciences and engineering has remained relatively steady over the last decade. However, the number of technical science / engineering students is projected to rise by 12-15% during the period 2010-2018, a faster rate than student growth across all subjects [11]. Across all disciplines, 44% of graduates from university are female [12]. However, there is a strong gender specific decline at higher academic levels – 37% of postdoctoral students are female, 29% of academic staff are female, 19% of post-docs are female and just 6% of professors are female.

There appear to be small differences between European countries, but the overall trend seems to be that the numbers of STEM graduates is roughly constant, despite increasing numbers of students entering higher education. In all of the countries, the under-representation of women remains a strong concern. Although the numbers STEM graduates has remained nearly constant, this should be taken in the context of industry’s demand for increasing numbers of STEM graduates, as discussed in the previous section. Furthermore, this must also be taken within the context of globalization. “International developments make the implications of this situation even more disquieting. Mature economies, such as that of the UK, must now compete with those of rapidly developing countries such as the BRIC nations - Brazil, Russia, India and China. On current projections the combined GDPs of the BRIC nations are set to overhaul those of the G6 countries (US, UK, Germany, Japan, France and Italy) by the year 2040. Furthermore, the BRIC nations are producing record numbers of graduate engineers. In China and India alone, the most conservative estimates suggest that around half a million engineers now graduate each year [6]."

4. How can the perception and popularisation of STEM subjects be improved?

Prof. Julia E. King, chair of the Royal Academy of Engineering's *Educating Engineers for the 21st Century Working Party,* said "at this time when our need for engineering talent is huge, and when our young people are increasingly interested in how they can help to save the planet, we are failing to persuade them that engineering careers are exciting, well-paid and worthwhile. … Much more must be done to ensure that school students perceive engineering as an exciting and rewarding profession that is worth pursuing. … Business and the professional institutions must do more to ensure that UK students recognise the attractiveness and rewards of an Engineering career. … In the longer term we will require measures to stimulate greater numbers of school students to study maths and physics, to encourage them to become engineering undergraduates and finally to opt to apply their qualifications in industry [4]." Furthermore, we need to find more effective ways to reach out to women and other under-represented socio-economic groups.

In order to reach out effectively to these groups, we must begin by looking at the public's perception of engineering. "Image, of course, is a long-standing topic for debate within engineering ... image at the level of the industry, the sector and the firm were all seen as important in getting bright youngsters onto engineering courses at university and recruiting and retaining good graduates within specific firms [3]." In order to reach out effectively to young people and women, it is also important to understand what stimulates their interest in science and technology and what motivates them to pursue STEM subjects in school. Finally, it is important to consider which media reach these groups.

The Royal Academy of Engineering and the Engineering and Technology Board jointly commissioned a group of social researchers to investigate public's perception of engineers and engineering. Their findings were published in the report *Public Attitudes to and Perceptions of Engineering and Engineers 2007*. This study found that the public has a limited initial awareness and understanding of engineering and engineers. Initial associations "put the profession into the role of building or fixing things rather than design, innovation or creativity [13]." Younger people were found to have a much more limited understanding of engineering than other groups. Positive attitudes were related to the belief that engineers provided many of the things people rely upon. Negative attitudes were related to the association of engineers as contributing to key societal problems (e.g. climate change). Younger people and women were less likely to be confident in their understanding/perception of engineering. Increased awareness/understanding of engineering had a clear positive impact upon people's interest in engineering. The report concluded that there was a clear need for increased public engagement and it "was felt that engineering was not depicted widely in the media [13]".

This study also found that people who claimed to know the most about engineering were least likely to say that engineering was a well respected profession. Much of the confusion and misperception of engineering was attributed to the use of the title "engineer" for non-engineering professions (e.g. television and heating engineers, etc.) – hence, the belief that engineers are people who "fix things". The people questioned in this study remembered "famous engineers such as Brunel and historical innovations in engineering such as the steam train, but were unable to name any modern day famous engineers who had invented anything considered to be of similar significance [13]." Engineering (and other STEM subjects) needs visible "heroes" and "champions."

The Henley study [3] also investigated what prompted students to pursue an engineering degree. The respondents "considered that engineering provided a good all-round degree which enabled the graduate to keep their career path options open – it provided the opportunity to 'change at any point – banking, more scientific roles, you can still change at a later time.' Secondly, there was a strong sense of wanting to make a difference, of contributing to society which culminated in something visible where the engineer could say 'I did that' and that it was 'great to see what you have designed and built.' Thirdly, there was the creative element, where engineering was seen as a creative subject with a strong practical dimension. The influence of parents was also important – several focus group members had parents who were pursuing engineering careers." These findings were broadly mirrored in the report *Public Attitudes to and Perceptions of Engineering and Engineers* 2007 [13] and the study *Educating Engineers for the 21st Century*, which said that the "key messages are the value of engineering to society (energy, climate change, care of the elderly, etc), the excitement of the technological challenges, and the good career prospects and salaries accessible through the study of engineering."

Public Attitudes to and Perceptions of Engineering and Engineers 2007 [13] also considered the avenues for reaching out to young people and observed that "television adverts and programmes were felt to be the most effective way of informing people…". The respondents most familiar with engineering also felt that "engineers should get into the media more [13]." Furthermore, video was seen as an effective medium, whose reach extended beyond television to the internet – distributed through sites like YouTube and AthenaWeb [14]. The impact of such sites for the popularisation of science, engineering and technology is of rapidly growing importance. For example, in 2008, the University of Nottingham's 'Test Tube' project [15-17] (the online showcase for the work of Nottingham Science City's resident film maker Brady Haran [18]) received an *International Business Award* in the category 'Best Public Information/Interactive and Multimedia' [19]. The internet is also an important channel for the dissemination and popularisation of scientific research in other formats. For example, the results of recent projects funded by the European Commission in the field of Information and Communication Technology (ICT) are presented on a dedicated website [20].

Finally, *Public Attitudes to and Perceptions of Engineering and Engineers* 2007 [13] also sought identify the particular characteristics of messages which stimulated young people's interest in engineering and technology, concluding the success of outreach activities is influenced by:

- *the "wow factor"...*

  The 'wow factor' does not relate to the complexity of the idea, but rather to the extent that the idea generated a sense of amazement. For example, the prosthetic leg developed for disabled sprinters was considered amazing because it not only allowed the athlete to run, but to run *very fast*. "Some aspects of science are thought of as inherently exciting, such as space travel or dinosaurs. But when properly presented, almost all science has the power to stimulate wonder and the imagination – from how cells function to the Big Bang. Communicating this, creating curiosity, helping people to ask questions and generating enthusiasm are the building blocks needed to stimulate interest in science [8]."

- *the simplicity of the idea...*

  Simple ideas are engaging because they are interesting, resourceful and easy to understand. On the other hand, complex ideas are more difficult to relate to. For example, “respondents felt a lack of interest in the BlackBerry because the innovation in Push Technology was difficult to engage with without understanding electronics [13].”

- *the contribution to social responsibility...*

  The social responsibility of engineering and technology is also important to the perception of technology. For example, “getting clean water into Ethiopia was felt to be a very positive example of engineering because it was helping people in a ‘life or death’ situation [13].” The application of science and technology in healthcare is also regarded positively. At the same time, it is important to avoid the ‘forensic science’ trap of training graduates in fashionable subjects for jobs which do not exist [4].”

- *the potential for large scale change...*

  “The ability of engineering to bring about large scale change in the world in a positive way resulted in greater engagement and interest [13].” For example, the Beddington Zero Energy Development was well perceived because of the potential to build new homes in a way which helps prevent further climate change.

- *the relevance to their own interests...*

  “Participants tended not to engage with examples of engineering – either positively or negatively, in cases where they did not feel it was relevant to them, their concerns or their interests [13].”

Finally, there were also indications that the relative importance of different motivating factors might be different for men and women. For example, women were perceived to be more motivated to pursue scientific and technical subjects perceived to be creative and which made a positive contribution to society [4].

5. What is being done to encourage 12-16 year olds to pursue STEM subjects?

The previous sections reveal Europe’s need for increased numbers of young people to pursue STEM subjects in school and, later, at university. Furthermore, there is a need to redress the under-representation of women and other socio-economic groups – particularly in the engineering and technology disciplines. “To increase the numbers of engineers, we need everyone to consider engineering as a career [2].”

In order to identify effective means for reaching out to young people and under-represented groups, it is helpful to have an overview of current outreach activities. There is a wide range of outreach actions, which can be broadly classified as: web based; competitions and awards; clubs; fairs and festivals; direct outreach actions, and curriculum support. There are also specific actions targeting women, including: “girls days” in Germany and Switzerland, the London Engineering Project (LEP) and WISE Outlook in the UK, and *elles-en-sciences* and *femmes-et-Science* in France.

The internet is widely used by students and has become an important outreach channel for the popularisation of science and technology. Because of the nature of the internet, the impact of these sites is not limited by national boundaries (although perhaps by language, as discussed later). In recent years, a number of sites have been developed for this purpose. For example, IBM and the Institute of Electrical and Electronics Engineers (IEEE) jointly launched the sites www.tryengineering.com and www.trynano.com as a “resource for students, their parents and their school counsellors [21-22].” (TryEngineering is available in 8 languages – Chinese, English, French, German, Japanese, Portuguese, Russian and Spanish.) These sites provide exciting insights into different fields of engineering and nanoscience. Teaching and learning resources are also made available, including lessons and listings of student opportunities ranging from summer camps and competitions to internships. Young people can also find out what it is like to be a scientist or engineer from real scientists and engineers (and also from science and engineering students). They also provide information about degrees offered by different universities. The site www.scenta.co.uk [23] seeks to encourage young people to explore STEM careers by providing career development and networking resources. It also acts as a source of exciting news stories about science and technology.

Other websites, like www.PhotonicsExplorer.eu [24] and www.athenaweb.com [14] provide online resources for teachers and professionals. The EXPEKT project, funded by the European Union, has brought together secondary school teachers, scientists in photonics and pedagogy and other organisations (including industry) to develop the ‘Photonics Explorer’ – a photonics educational kit for Europe’s secondary schools. This intracurricular educational kit is designed to “really engage, excite and educate students about the fascination of working with light [24].” Furthermore, these materials will be provided in 7 European languages - Bulgarian, Dutch, English, French, German, Polish and Spanish (although the website itself is only in English). AthenaWeb is specialised in the provision of video materials (organised into 20 different scientific categories) and seeks to be the “‘YouTube’ for science and audiovisual professionals”. “Shrinking science classrooms are an ominous sign that action is needed. With AthenaWeb, educators have at their disposal a goldmine of audio-visual content to spice up classes and curricula [14].” Although AthenaWeb provides public access to hundreds of non-broadcast quality videos, access to most of the broadcast quality films is restricted to registered users (due to copyright issues).

Apart from the web-based actions, such as those described above, most outreach activities are organised and delivered in a variety of formats at the national level. Some of these are competitions and awards (e.g. F1 in schools, BA CREST Award, Robocup Junior UK). Others are clubs (e.g. Computer Club 4 Girls, Imagineering Clubs, Young Engineers Clubs). Fairs and festivals (e.g. Fête de la Science, Big Bang Fair, Cheltenham Science Festival) are also popular outreach channels. There are also a number of direct outreach actions, which actively reach out into local communities to introduce young people to science and technology. These range from scholarships, to travelling laboratories and lecture series, and even to practical short courses (e.g. Mädchen Zukunftstag or girls day, Arkwright Scholarships, Lab in a Lorry, Smallpiece Trust STEM enrichment days, LEP). Finally, there are a number of important indirect outreach activities relating to curriculum support (e.g. CAD/CAM in Schools, Nuffield Foundation Secondary D&T, Technology Enhancement Programme). In the **Appendix**, we provide further examples of outreach activities implemented in Europe at the national level, including a brief description of each. Through these examples, we try to give an idea of the type and scope of the different outreach activities, but this list is by no means comprehensive.

The Henley report cautions that “understanding graduate skill formation involves recognising the interdependence of schools, universities, firms, and government, along with broader issues such as social attitudes to science and engineering. Such an institutionalist perspective underlines the complexity of the topic and cautions against looking for a simple fix [3].” The outreach activities described in this section (and the Appendix) reveal a wide range of high quality activities across a broad front. Furthermore, these activities show the involvement of all of the major stakeholders, including schools, colleges, universities, professional organisations, government and industry. Nevertheless, there are still some points for real concern:

1. There is evidence of serious fragmentation of these activities – both within a single country and across Europe.
2. Most of the websites and materials are only available in a single language (except where it is mentioned otherwise) – usually English. Our experience within the BRIGHTer project showed that there was considerable demand for materials produced in the local tongue, suggesting that it is worth the effort to translate materials into other languages. (This is particularly true for materials intended to reach out to the general public – and especially young people.)
3. There are too few visible role models in science and engineering. For example, when asked, few people can tell you who invented the integrated circuit, the laser or even the internet – even though most would agree that these inventions have changed modern society!
4. There is a lack of quantity and breadth of TV programs which target young people and portray modern science and engineering as creative and exciting. This is particularly worrying since "television adverts and programmes were felt to be the most effective way of informing people [13]."

The final point is particularly important, since TV reaches the widest group in our society. "The appetite for science, health and environmental stories in the national media is voracious with a huge number of stories appearing most days. There are many signs that editors value their specialist reporters, arguably science's biggest allies, and we should nurture this relationship. The DIUS/RCUK survey showed that a majority of people still obtain their science information from TV, leading to a concern over the decrease in quality documentaries and the use of credible science in other programming [8]." This report continues to say that there should be an "increase in and widening of the diversity and coverage of science on TV, as this is acknowledged to be the main source of information."

6. Ways EC research projects help popularise STEM subjects among students.

In this section, we consider some ways in which the EC and EC-funded research projects could help to address the four points made in the previous section. The objective is to stimulate new ideas and generate further discussions on these important issues.

Point 1 highlights the problem of fragmentation of outreach activities – both within member countries and across the EU. Although an important issue, it is not clear how EC-funded research projects could contribute to addressing this.

Point 2 highlights the importance of providing the public (and the national media) with material in their native language. As EC projects have partners from multiple countries, it would seem reasonable for key documents targeting the popularisation of results (e.g. press releases, etc.) to be translated into the languages represented within the particular Consortium.

Point 3 raises the problem of too few visible role models in science and engineering. Perhaps the EC could do more to identify and publicly recognise innovation – perhaps by introducing something similar to the German Future Prize (Deutsche Zukunftspreis) to identify projects which of high scientific value, have concrete applications and are mature for commercial markets.

The public identification of role models in science and technology represents only one aspect of the solution to this problem. Science and technology should be celebrated proudly and publicly. For example, EC-funded projects could be encouraged to produce public exhibits for display in public places where they will be encountered by many people (e.g. airports, major train stations, etc.). EC help would be required to secure the venues and an EC-sponsored design consultant could easily ensure that the exhibit was of the right quality and pitched at the right level by working with the project teams. From the perspective of the EC-project resources, this would compare favourably (in terms of both time and cost) to other EC sponsored events. For example, in addition to the cost of producing their exhibit (which would also be incurred here), the ICT-2008 event in Lyon cost projects €3000 to €7000 and 2-5 person-weeks (mostly in the personnel and travel costs associated with the exhibition) for an exhibition time of less than a week. Furthermore, this event reached public policy makers, other European researchers and industry representatives, but did not generally reach out to the general public. On the other hand, an exhibit at an airport or train station could be an unattended exhibit, which would be on display for a longer period of time (e.g. a month, before moving to another location) and would reach tens of thousands of ordinary people.

Finally, point 3 is also related to point 4 – the lack of a strong presence of science and engineering in the TV media, which is discussed below.

Point 4 highlights the problem that there is a lack of quantity and breadth in TV programs to popularise science and technology. This is the point which we feel that EC, together with EC-funded research projects, can and should do much more. Consequently, we will focus on this point for the rest of this section.

The objective is to address the question “How can the media better support society’s need for balanced information that accurately portrays the nature of science and improves scientific literacy? … What more can the science community and the media do to improve understanding of the nature of science? … How can the lack of quantity and breadth of science television on terrestrial and other channels be addressed? [8] Although the internet is an important information resource for young people, those most likely to visit websites devoted to the popularisation of STEM subjects are those who are already curious about science and technology. In order to stimulate the interest of more young people, the message must also be delivered by more mainstream media such as television and YouTube.

The report *A Vision for Science and Society* says that “There is scope too for making public engagement less reliant on voluntary activity and for it to be perceived as more professional in its approach and a valued part of the work of scientists. There is more need for strategic thinking about what is being done well, what gaps there are and what needs to be done better, and for the best in public engagement to be incentivised and rewarded [8].” Most of the scientists we have interacted with in European research projects believe that it is important to popularise their research results and are committed to the goal of stimulating more young people and women to pursue careers in science and engineering. However, when faced with the task of making a film for the purpose of popularisation, researchers rapidly encounter several problems:

a) They have little or no experience presenting their work at the correct level for the general public. “Scientists would prefer scientific stories presented by the media to demonstrate its uncertain nature and risks, whilst the tendency of the non-specialist media is to present a much more black and white picture… there is a continuing need for a more sophisticated portrayal of the nature of science, and in particular what science can and cannot do [8].” This becomes even more difficult when they are asked to address the key target groups: young people and women. This requires someone with the proper training in pedagogy.

b) They have little or no experience with film media. Even when you have a good idea of how to pitch your presentation, this doesn't mean that you will be able to produce a quality film or video. "Engagement is becoming more professional, based on good practice, and often involves specific support, such as high quality media training [8]." This requires a filmmaker with suitable training and experience.

c) They have little or no experience with the marketing and distribution of films. This requires experience and good contacts with television stations.

We believe that the European Commission could address these problems in a relatively cost-effective manner by engaging a team (or project) to produce films to popularise the results of successful EC-funded research projects. This team would include filmmakers, TV presenters and experts in pedagogy and sociology to ensure the necessary skills are available at a high professional level. The team leaders and EC project officers would decide which projects and results were most likely to be suitable for popularisation in this manner. The production should target more than one audience (i.e. country) by using subtitles or dubbing. The films would be distributed and shown widely on television using the team's (and the European Commission's) contacts. Indeed, many television stations would probably be prepared to actively engage with this process.

This would have benefits for all involved. European society would benefit from the stimulation of greater interest in science and technology, motivating more young people to pursue careers in these areas. The European Commission would benefit by increased public awareness of European research activities. The companies, research laboratories and universities would benefit from greater public visibility.

7. Conclusions

The popularisation of science among young people and girls is critically important for inspiring them to pursue careers in science, engineering, technology and mathematics. They will be responsible for developing and sustaining tomorrow's technology - with all of its impact on the economy and society.

Industry expects a strongly increasing demand for high calibre STEM graduates. This demand will be fuelled by an increase in the number of STEM graduates in the workforce, the replacement of retiring staff in an aging population and the need to meet the challenges of globalisation. Globalisation is a major challenge facing European industry and will continue to have a major impact upon both the supply and demand sides of the economy. The rapid growth outsourcing manufacturing to countries with lower labour costs will force European engineering in all areas to concentrate on higher value-added activities. Action is needed to address the shortage of high-calibre engineers entering industry – otherwise, the shortage of quality graduates will have serious repercussions for productivity and creativity. Certain disciplines (e.g. electrical and electronic engineering, systems engineering, information and communications technology, and materials) are perceived to be of particular importance.

Despite small differences across Europe, the overall trend seems to be that the numbers of STEM graduates is roughly constant – even though there are increasing numbers of students entering higher education. This means that the percentage of young people choosing STEM careers is in decline. Furthermore, the under-representation of women remains a strong concern across Europe. These trends should be taken in the context of industry's demand for more STEM graduates and in the context of increasing globalisation. European economies must now compete with those of rapidly developing countries, such as the BRIC nations (Brazil, Russia, India and China), who are producing record numbers of graduate engineers.

Prof. Julia E. King, chair of the Royal Academy of Engineering's *Educating Engineers for the 21st Century Working Party,* said "at this time when our need for engineering talent is huge, and when our young people are increasingly interested in how they can help to save the planet, we are failing to persuade them that engineering careers are exciting, well-paid and worthwhile." To reach out effectively to these groups, we must begin by looking at the public's perception of science and technology. We must understand what stimulates their interest and motivates them to pursue STEM subjects in school. There is a clear need for increased public engagement and a larger media presence – particularly in television.

Positive attitudes were related to the belief that engineers and scientists provided many of the things people rely upon. Increased awareness/understanding of engineering impacts positively on people's interest in engineering. The success of outreach activities among young people is influenced by: the 'wow factor'; the simplicity of the idea; the contribution to social responsibility; the potential for large scale change; and the relevance to their own interests. Women were more motivated to pursue scientific and technical subjects perceived as creative and contributing to society.

There is already a wide range of outreach actions to encourage young people to engage with science and technology. These can be broadly classified as: web based; competitions and awards; clubs; fairs and festivals; direct outreach actions, and curriculum support. There are also specific actions targeting women. Nevertheless, there are still points for real concern:

1. There is evidence of serious fragmentation of these activities – both within a single country and across Europe.
2. Most websites and materials are only available in a single language – usually English.
3. There are too few visible role models in science and engineering.
4. There is a lack of quantity and breadth of TV programs which target young people and portray modern science and engineering as creative and exciting.

Finally, the report considers a few ways in which the EC and EC-funded research projects could help to address these four points:

- It is important to provide the public (and the national media) with native language materials. Key documents targeting the popularisation of results (e.g. press releases, etc) could be translated into the languages represented within a Consortium.
- The EC should do more to publicly celebrate innovation- perhaps something like the German Future Prize (Deutsche Zukunftspreis) to recognise projects of high scientific value, with concrete applications and mature for commercial markets.
- EC-funded projects could be encouraged to produce public exhibits for display in public places (e.g. airports, major train stations, etc.) where they will be encountered by tens of thousands of ordinary people.
- The EC could fund a team (or project) to produce films to popularise the results of successful EC-funded research projects. This should involve filmmakers, TV presenters and experts in pedagogy and sociology to ensure the necessary skills are available at a high professional level. The team (and the European Commission) could use their contacts to ensure that the film was distributed and shown widely.

References

1. *"WWW_BRIGHTER_EU Publishable Final Activity Report,"* and other dissemination, training and popularisation documents from the WWW_BRIGHTER_EU project, http://www.ist-brighter.eu/
2. *"Pioneering Engineering Education,"* The London Engineering Project, sponsored by the Higher Education Funding Council for England (HEFCE) and the Royal Academy of Engineering (RAEng), http://www.raeng.org.uk/news/publications/list/reports/Pioneering_engineering_education.pdf
3. *"Educating Engineers for the 21st Century: The Industry View,"* prepared by Henley Management College for the Royal Academy of Engineering, 8 March 2006, http://www.raeng.org.uk/news/releases/henley/pdf/henley_report.pdf
4. *"Educating Engineers for the 21st Century,"* Royal Academy of Engineering, June 2007, http://www.raeng.org.uk/news/publications/list/reports/Educating_Engineers_21st_Century.pdf
5. "*STEM Briefing,"* the Russell Group of Universities, http://www.russellgroup.ac.uk/uploads/STEM-briefing.pdf
6. *"Engineering Graduates for Industry,"* the Royal Academy of Engineering, February 2010, http://www.raeng.org.uk/news/publications/list/reports/Engineering_graduates_for_industry_report.pdf
7. *"Science and Innovation Investment Framework 2004-14: Annual Report 2007,"*HM Treasury, Dept. for Innovation, Universities and Skills, July 2007, http://www.berr.gov.uk/files/file40538.pdf
8. *"A Vision for Science and Society,"* Department for Innovation, Universities and Skills, July 2008, http://webarchive.nationalarchives.gov.uk/tna/+/http://www.dius.gov.uk/consultations/documents/A_Vision_for_Science_and_Society.pdf/
9. http://media.education.gouv.fr/file/2009/94/5/chap6-3_73945.pdf
10. http://www.stat.gov.pl/cps/rde/xbcr/gus/PUBL_as_concise_statistical_yearbook_of_poland_2009.pdf
11. http://www.bfs.admin.ch/bfs/portal/de/index/themen/15/08/dos/blank/15/07.html
12. http://www.bfs.admin.ch/bfs/portal/de/index/themen/15/06/data.html
13. *"Public Attitudes to and Perceptions of Engineering and Engineers 2007,"* prepared by Helen Marshall, Lynne McClymont and Lucy Joyce of BMRB Social Research and BMRB Stakeholder for the Royal Academy of Engineering and the Engineering and Technology Board, September 2007, http://www.raeng.org.uk/events/pdf/Public_Attitude_Perceptions_Engineering_Engineers_2007.pdf
14. http://www.athenaweb.org
15. http://www.test-tube.org.uk/
16. http://www.periodicvideos.com/
17. http://www.sixtysymbols.com/
18. http://www.bradyharan.com
19. http://www.nottingham.ac.uk/public-affairs/press-releases/index.phtml?menu=pressreleasesarchive&code=NOT-158/08&create_date=02-jul-2008
20. http://cordis.europa.eu/ictresults/
21. http://www.tryengineering.org
22. http://www.trynano.org
23. http://scenta.co.uk
24. http://www.PhotonicsExplorer.eu
25. *"The 'shape the future' Directory of Engineering and Technology Enrichment Activities for Schools and Colleges,"* the Royal Academy of Engineering, January 2008, http://www.raeng.org.uk/news/publications/list/reports/stf_directory.pdf
26. http://www.raeng.org.uk/societygov/public_engagement/activities_events/default.htm
27. http://www.cnrs.fr/mpdf/spip.php?article292

28. http://www.education.gouv.fr/cid4006/egalite-des-filles-et-des-garcons.html
29. http://www.education.gouv.fr/bo/2007/5/MENE0603248X.htm
30. http://www.elles-en-sciences.org/elles-en-sciences
31. http://www.femmesetsciences.fr/
32. http://www.langenachtderwissenschaften.de/archiv/lndw_2009/
33. http://www.opticscamp.dk/
34. http://www.fuw.edu.pl/popularyzacja-nauki.html
35. http://tochtertag.ch

Appendix

The examples listed in this Appendix give an idea of the type and scope of outreach activities targeting young people and women. However, this list is by no means comprehensive. In fact, since the authors of this report are based in the UK, most of the examples are from the UK. However we have also included some activities in other European countries, which we have been made aware of by colleagues in the WWW_BRIGHTer_EU integrated project.

UNITED KINGDOM

There is a wide range of outreach actions [25], which can be broadly classified as: competitions and awards; clubs; fairs and festivals; websites; direct outreach actions, and curriculum support.

Competitions & Awards:

- *4x4 in Schools* Teams of 4-6 young people design and build a remotely controlled 4-wheel drive vehicle able to negotiate a challenging road and a range of obstacles.
- *BA (British Association for the Advancement of Science) CREST Award* This is a nationally recognised accreditation scheme for project work in the fields of science and technology, which encourages students to develop their scientific curiosity, problem-solving and communication skills.
- *FIRST LEGO League* This scheme combines hands-on, interactive robotics activities with a sports-like atmosphere to promote team-building, problem solving, creativity and analytical thinking.
- *F1 in Schools* Students design a model CO2-powered F1 car of the future using computer aided design. After their design is produced using a computer numerical control machine, it is tested and the students compete with other students.
- *Future Flight – Greener by Design* This is a web-based competition to produce an innovative and environmentally friendly design for a futuristic airliner for 2050.
- *Go4SET* This scheme links teams of 6 students (year 9) and their teacher with companies for a 10 week science, engineering and technology (SET) experience. The scheme has a competition format and prizes are awarded in a number of categories.
- *Greenpower F24* In this initiative, groups of students design and build an electric car according to a specification. In this scheme, everyone gets involved, including teachers, parents, co-opted engineers and sponsoring companies.
- *Independent – Bosch Technology Horizons Award* This is an essay competition, which challenges young people to express their views on how technology has impacted society now and in the future.
- *NESTA Famelab* This national competition, created by the Cheltenham Science Festival and the National Endowment for Science, Technology and the Arts (NESTA), seeks talented engineers and scientists “who can share their enthusiasm and knowledge with the public – the ‘new voices of science, engineering and technology’.” Winners and finalists have appeared on national television and radio.
- *RoboCup Junior UK* Students design and build robots to perform specific tasks (e.g. dancing, playing football). This competition is designed to promote science, technology, engineering and mathematics.
- *TrackNAVCHALLENGE* In this competition, students are challenged to design and build a radio controlled, four wheel drive model vehicle that emulates the all-terrain capabilities of a Land Rover.

- *Toyota Technology Challenge* This is an educational, fun and affordable school-based national technology competition (sponsored by Toyota Manufacturing UK and Rapid Electronics Ltd.) to build an environmentally friendly motor vehicle.
- *Young Engineer for Britain* This is a national celebration of the best creative projects from students, providing a regional and national showcase for engineering technology and design achievement.
- *Young Foresight* In this scheme, pupils work in teams to design future products and services, developing their own design briefs and specifications.

Clubs:

- *Computer Clubs 4 Girls* This is an innovative and award-winning initiative designed to raise the standard of girls' ICT skills, while transforming their attitudes towards careers in IT.
- *Imagineering Clubs* These are aimed at encouraging young students (8-12 year olds) to become interested in engineering and science.
- *Young Engineers Clubs* There is a network of > 1500 active Young Engineers Clubs across the UK, with a national activity bank of suitable activities. Club achievements are celebrated via the Club of the Year competition and regional showcases.

Fairs & Festivals:

- *BA (British Association for the Advancement of Science) CREST Fair* This fair celebrates creativity in science and technology. It is the culmination of regional fairs, which exhibit outstanding research projects by young people.
- *Big Bang Fair* This is "the UK's biggest science and engineering fair to celebrate the achievement and excellence of young people through the National Science and Engineering competition, while engaging and inspiring them with a wide range of exhibits, activities, presentations and events [26]."
- *Cheltenham Science Festival* Established in 2002, The Cheltenham Science Festival has grown to become one of the most significant science festivals in the UK. It offers young people the opportunity to "engage in entertaining, challenging and deliberately controversial issues and experiences" with respect to science and technology. The 'Discover Zone' is the main feature of the festival, which is billed as 'interactive science for all ages.'
- *Imagineering Fairs* These major annual events consist of stands with fun, interactive projects for young people (and their parents). These stands are provided by industry, universities, schools and other institutions.
- *Youth Engineering Show* This one-hour show, which runs for several days for schools in one location, considers the "role of engineers in creating the world around us, from bridges, ships and software to cars, mountain bikes and mobile phones [25]."

Direct outreach:

- *Arkwright Scholarships* These scholarships, funded by industry and charitable trusts, are designed to encourage 15-16 year old students to pursue careers in engineering and technology.
- *BAE Systems Schools Roadshow* This roadshow is designed to inspire young people about careers in science and engineering. It involves a 30 minute theatre piece and a 1 hour practical workshop. It makes two tours each year to cover the UK.

- *IOP Schools and Colleges Lecture Series* These lectures are given across the UK by a series of acclaimed physics communicators. These illustrated lecture-demonstrations are designed to show modern applications of physics to students in a fun way.
- *Lab in a Lorry* These are mobile science labs which seek to generate enthusiasm for science and engineering among young people by giving them the opportunity to explore a series of hands-on experiments.
- *London Engineering Project* This is a £2.82M project funded by the Higher Education Funding Council of England (HEFCCE) and the Royal Academy of Engineering in 2005 to create "a partnership of national organisations and some 50 London schools together to get more women, more black and minority ethnic (BME) students and more students from families with no previous footprint in HE to opt for engineering degree courses [2]."
- *Smallpiece Trust 4-day residential courses* These courses, which take place at Universities and other secure locations, are designed to further develop students' interest in engineering and have an emphasis on creativity, design and team work. Students have access to materials and equipment not available at school and gain experience of university and industry, which enhances their personal development. There is also a supervised social programme in the evenings.
- *Smallpiece Trust STEM enrichment days* The Smallpiece Trust organises sessions in schools for students in years 8 and 9 to enhance their understanding of, and aptitude for problem solving, creativity, design and engineering.
- *WISE Outlook* This 3 day programme run at local colleges allows girls (year 9) to experience engineering firsthand. They work on hands-on engineering projects and meet young women engineers to learn about their work and careers.

Curriculum Support:

- *CAD/CAM in Schools* This programme, managed by the Design and Technology Association, offers industry standard software to secondary schools, 6th form colleges, and to all teachers enrolled on design and technology courses.
- *Electronics in Schools Strategy* This scheme seeks to positively engage students in learning about electronics and its applications. It provides teaching resources and teacher training to raise standards in electronics and communications technology learning and teaching.
- *IET Faraday* This scheme introduces young people to the world of science, engineering and technology, inspiring them with a programme of specially made films, student challenges, events, school visits and teaching resources.
- *INPUT (Industry Projects Understanding Technology)* INPUT projects link industry and education in exciting ways. Projects are designed to be interesting and provide insight into technology. They vary in duration from 1-5 hours (depending on age group).
- *IOM3 Schools Affiliate Scheme* In this scheme, the Institute of Materials, Minerals and Mining provides teaching resources and school visits to support the teaching of the materials, minerals and mining related topics in the Science and Technology curricula and to raise awareness of careers in materials, minerals and mining engineering.
- *National Teaching and Learning Change Programme: Engineering* This programme provides a suite of engineering learning resources for teachers and students.
- *Nuffield Foundation Secondary D&T* This curriculum development project produced a wide range of materials for students and teachers, which are available free of charge on their website.

- *Technology Alliance Wales* This organisation, comprised of representatives from education, industry and government, introduces new initiatives through 4 training centres in Wales. “TAW has supported and pioneered the use of new technologies in schools to improve the quality of technology education in Wales and to encourage pupils to enter our engineering, manufacturing and technological industries [25].”
- *Technology Enhancement Programme* This programme works with schools, colleges, educational and industrial partners to develop leading edge design technology and engineering curriculum resources for secondary schools and colleges.
- *whynotchemeng* In this scheme, the Institution of Chemical Engineers provides free teaching resources to schools to raise the profile of chemical, biochemical and processing engineering in schools.

FRANCE

Many organisations in France are concerned with the promotion of science and many have a special emphasis towards young women and girls. Some of these are discussed below.

The *Fête de la Science* (Science Fair) is organised every year and is dedicated to primary and secondary schools, with a large participation of parents. It lasts 3 days, with many events all over the country and visits of research laboratories.

At CNRS, the "Mission pour la place des Femmes au CNRS" (The Mission for the place of Women) [27] seeks to design and implement an action plan for the promotion of the role of women at CNRS. The goal is to ensure the coherence of all activities undertaken in this regard, to give its opinion on the conditions of their implementation, to coordinate the procedures, evaluate the results and propose all useful measures as likely to promote the place of women at CNRS. In particular, the Mission has published a book *Women in the History of CNRS*. It has contributed to various travelling exhibitions like *Women in Physics* which promote female scientists in technology, research and science and has produced short films about two women Nobel Prize laureates, etc... These books and movies are especially dedicated to young girls and boys, in order to make them aware of scientific careers through conferences and debates organized in schools.

The French Ministry of Education is also concerned with the equality between boys and girls, and the promotion of sciences [28]. The goal set in 2006 was to reach 44.6% of girls in science and technology at the end of secondary school (*baccalauréat – obtained at the age of 18 years*) in 2010, corresponding to a 20% increase of the proportion of girls. To reach this aim, there have many communication activities to provide girls and boys a better overview of their professional choices, as well as to provide information about gender in professions, and to promote scientific and technology. A governmental convention, involving not only the Education Department, but also the Justice Department, the Culture & Communication one, the Agriculture Department, was signed in 2006 to coordinate these actions [29].

Elles en Science [30] and *Femmes et Sciences* [31] are associations which promote science and technology professions amongst young students and particularly (but not only) young women and girls.

GERMANY

In Germany, there is strong support in industry for encouraging girls to engage with science and technology. One well known example is the Annual Girls Day (Mädchen-Zukunftstag für Schülerinnen ab Klasse 5 - Encouraging girls to deal with natural sciences starting in grade

5), which is held nationally and has wide support and participation from companies and institutes across the country. Another science popularisation event is the Lange Nacht der Wissenschaften ("Long Night of Sciences"), which is organized by the local government of Berlin [32].

DENMARK

In 2008, 2009 and 2010, Paul Michael Petersen and Karsten Rottwitt arranged an "Optics Camp" at DTU Fotonik for high school students for 1 week in July [33]

POLAND

The Department of Physics at Warsaw University organizes many presentations for school students, both at the faculty and in schools. Their audience is about 10000 kids annually. The program [34] includes numerous activities for the popularisation of science, including:

- advanced physics lectures for high schools;
- advanced physics lab sessions for pupils;
- seminars for physics teachers;
- a public access web page 'Ask a question about physics' (run by a team of academic teachers from the Warsaw University);
- a physics summer schools for pupils;
- an annual festival of science;
- the programme: 'talents in physics' to find talented candidates to study physics; and
- popularisation by the Polish Physical Society (e.g. popular TV & radio programs).

SWITZERLAND

Switzerland also has a national program of promoting technical careers amongst 12-16 year old girls, which is called nationaler Tochtertag (national daughters' day) [35].