Science, technology, engineering and mathematics education in EMEA

advancing the agenda through multi-stakeholder partnerships
This white paper, *Science, technology, engineering and mathematics education in EMEA: advancing the agenda through multi-stakeholder partnerships*, is published jointly by Intel and European Schoolnet, and is the second in a series of publications resulting from the Intel Educator Academy events in Europe Middle East and Africa (EMEA). The initial white paper - *Science, technology, engineering and mathematics education: overcoming challenges in Europe* - an outcome of the first Intel Educator Academy EMEA, held in London, UK, in March 2011, where 85 key figures on STEM education from the EMEA region reviewed and evaluated STEM education strategies, and in particular the use of inquiry based learning.

In this second white paper, we further explore STEM education, highlighting specific country and regional practices, and make further recommendations for the future. This paper builds on discussions at the 2012 Intel Educator Academy EMEA which took place in Bratislava, Slovakia under the patronage of the Prime Minister Mr. Robert Fico, combined with the outcomes of research carried out through inGenious, a ground breaking multi-stakeholder initiative, coordinated by European Schoolnet and supported by Intel, that fosters school and industry collaboration in STEM education and career advice. inGenious - the European coordinating body for STEM education, led by European Schoolnet - partnered with Intel for the event, along with the European Union Contest for Young Scientists, and the Young Scientists of Slovakia.

The Academy convened key figures from teacher professional development and industry as well as STEM education policy fostering new partnerships and deepened existing ones to help unify efforts and tackle the major challenges in STEM education across the EMEA region. The stakeholders consulted for this paper have strong ability to influence the STEM education sector whether from an informal or formal education perspective. They include Ministries of Education, NGOs, science fairs and business.

We owe thanks to the review team who gave their input into the draft of this paper before publication: Professor Derek Bell (Director, Campanula Consulting, UK), Sebastiaan Smit (project manager at Platform Beta Techniek in the Netherlands), Maya Halevy (Director of the Bloomfield Science Museum, Israel), Jon Price (Director of Research at Intel USA) and Emma Bluck (Director at Goldspark Consulting, France).

**Introduction**

STEM education is of critical importance in the EMEA region to plug the skills gap and address the high level of youth unemployment. The region has the highest levels of youth unemployment in the world according to the World Economic Forum, with one youth in four without a job. Meanwhile demand for STEM talent in jobs continues to rise, especially as the STEM qualified population is now rapidly ageing. This poses an economic and social threat to the region’s social cohesion, as well as its ability to compete economically and drive new innovation. Young people are failing to capitalise on the opportunity that STEM can bring to them: most developed countries show low interest and achievement in STEM among young people, and in Europe, there is a decline of around 10% in terms of numbers of graduates. Women and girls are still also under-represented in STEM, for instance, they represent only 20% of graduates in computing and engineering.

Achievement in EMEA in STEM education is below the global average according to TIMMS. Meanwhile, China has more than quadrupled its number of STEM graduates since 2000 to nearly 2 million in 2006, and students in Shanghai are among the best in the world in STEM achievement: the EMEA region needs to do more to compete.

Through discussions with key experts, we have identified four major areas of work which can help address the situation and improve interest in STEM education and careers: working with schools and teachers, engaging girls in STEM, widening the impact of science fairs, and building and sustaining effective partnerships.

For each theme, we will re-examine the relevant recommendations raised in the previous edition of the white paper and assess progress towards addressing them. In particular, we will highlight advances based on collaboration and partnerships between previous Intel Educator Academy attendees. We will then consider what remains to be done to address challenges related to the theme. The white paper concludes with fresh recommendations and calls for action.
Working with schools and teachers
Science, technology, engineering and mathematics education in EMEA

Working with schools and teachers

Schools and teachers are the keystone to increasing student motivation for STEM studies and careers. Every young person is exposed to STEM through their formal schooling, and thus improving the STEM experience at school is of the utmost importance. According to international surveys like TIMMS, traditional teaching styles dominate maths and science teaching in most countries compared to other subjects; student-centred learning is relatively rare. In particular, there is still a clear need for more contextualisation of STEM content in schools, as this has a positive impact on student motivation in the subject - this is particularly crucial in maths - as reported by the OECD. 20% of students are more interested in STEM when “real life” content is introduced alongside theory.

Unless students gain understanding of how STEM serves society, teachers are at a disadvantage in trying to encourage students to work on STEM content. This applies especially to girls. The TALIS survey of OECD particularly underlines the need to train and support STEM teachers in moving to more modern teaching methods.

In the previous white paper, two recommendations relevant to schools and teachers were made which aim to tackle the issues outlined above:

1. Enhance and reform STEM curricula, pedagogy and assessment
2. Reward, train and support teachers in innovative approaches

Where are we now?
Progress across countries in the EMEA remains uneven in curricular reform: there is no international mandate for institutions such as the European Commission or UNESCO to set international standards in STEM education at primary and secondary level across the region, so progress is entirely dependent on national priorities. Too often in schools, we find that STEM curricula focus mostly on science, maths and, to a limited extent, technology but with relatively little engineering content. And even where a wider range of content is included, it is not always effectively put into context. However some countries have recently made efforts to reinvigorate curricula, e.g. the UK, France, the Netherlands and Israel. Continuing professional development is currently under major change: there are increasing numbers of informal programs available across the region, while formal systems struggle to maintain existing strategies due to budget restrictions.

The enhancement and reform of STEM curricula was a key objective in the UK since the previous white paper was published. In particular, lower secondary science curricula were reformed to tackle more current issues-based approaches, linked to societal challenges, such as climate change and future energy needs, with a positive impact on the number of students taking such qualifications. This reform has had a positive knock-on effect on upper secondary participation in STEM, with an increase in the number of students taking electives in physics, maths, chemistry...
and biology. Another reform has includes programming and computer science at primary school level and ICT is proposed to be replaced by computing at all ages in 2014.

French reform in 2011 also introduced new scientific approaches in STEM curricula, for instance aiming to develop students’ critical thinking skills, an understanding of the importance of observations and experimentation. Meanwhile in the Netherlands, a new reform has been announced, linked to the new Techniekpact (Technology Pact) which aims to ensure the Netherlands remains a world leader in technology skills. By 2020, all primary schools will integrate science and technology into their curricula, and benefit from teacher training and support from business to tackle the subjects effectively.

In Israel, several reforms have been launched in the last years focusing on improving the level of STEM achievement at secondary school and introducing engineering in primary school curricula among other topics. “We are the Future”, targeting upper secondary, is a holistic program linking Intel, the national Ministry, the high-tech industry, academia and NGOs. This aims to increase the number of secondary school leavers with high results in STEM from 6% to 20% by 2020. Meanwhile, “ENGINEER”, aimed at primary schools, brings engineering topics into curricula. It results from a European funded research consortium, coordinated by the Bloomfield Science Museum. Pupils are given the opportunity to participate in “engineering challenges” in various fields, using an engineering design approach. The introduction of these new topics was supported by teacher training and teacher guides.

Engineering is also a key focus in Saudi Arabia: a new program “Engineering is Elementary” designed for young children in partnership with the Museum of Science, Boston and the pan-Arab business and education organization Injaz, is now launching “The Little Engineer” curriculum in the Kingdom of Saudi Arabia. Engineering is Elementary has created a research-based, classroom-tested curriculum that integrates engineering and technology concepts and skills with elementary-level science topics. The program encourages elementary school educators to enhance their understanding of engineering concepts through professional development workshops and curriculum resources.

In contrast with the above subject focused approaches, Flemish Belgium, Ireland and Malta have introduced more general curricular reform, moving to a more competency-based model of teaching and learning at primary and/or secondary level. Such competency-based models tend to encourage more focus on innovative approaches such as inquiry-based learning. However few countries have made a dedicated effort to reform STEM curricula more specifically. Flemish Belgium - via the Flemish Network for Science and Innovation - recently conducted a review of factors influencing student motivation for choosing STEM studies, and recommended STEM curricular reform.

In terms of local projects, there are some good examples, even if they are not taken up in a systemic way. In Finland, where schools have relative autonomy, a new model of school has been developed via a partnership between Nokia and Paviola upper secondary school in Helsinki. The school recruits talented students to follow an innovative program mixing hands on industry experience with their studies. For two days a week, the students work as interns at Nokia, while the remainder of the week focuses on academic activities.

Also in Scandinavia, the Swedish organisation Nobel Media has offered teachers innovative digital materials and activities based on Nobel laureate discoveries for use in class for more than a decade. A team of young developers help to give a fresh appeal to some well-known science topics such as Pavlov’s theory and blood typing. Interactive games were the most popular, and spread virally without any need for a marketing budget. For instance, the blood typing game has had 7 million unique visitors and is still used regularly despite being a decade old. On researching how students found their materials, they found 30% had received the link from their teachers, while others found it through use of Google for homework research. Teachers have also appreciated the “Chemistry Matters” series of videos, to help students understand the relevance of chemistry in life.

Such innovative resources show that even strict and traditional curricula can be interpreted in very different ways. Past European projects funded under the 7th Framework Programme have indicated that experienced teachers with strong pedagogical understanding and confidence in using innovative techniques find they can “get around” more traditional curricula. For instance, using collaborative and inquiry based approaches can be used to examine topics in place of traditional “from the front” teaching. Similarly, the integration of more informal learning at home is common, and attendees at the Academy underlined the importance of science museums in supporting informal learning whether
in the family in leisure time, or via school visits, and training for teachers in making the most of innovative materials and topics. This view has been supported by findings in the OECD’s PISA studies.

Since the first Intel Educator EMEA, much progress has been made in terms of offering more teacher support among the stakeholders attending the events, particularly in the area of continuing professional development (CPD). The variety and volume of dedicated STEM training offered, according to the debates, appears to have increased.

A good example comes from Intel itself, with the development of new inquiry based face-to-face and online training curricula such as Intel Future Scientists or Inquiry in the Science Classroom (http://www.intel.com/content/www/us/en/education/k12/teach-elements.html). There are also numerous teaching materials in innovative formats provided to teachers through Intel’s Skoool program, (http://www.intel.com/content/www/us/en/education/k12/k12-educators.html).

The European Commission has continued its focus on this area through actions funded under the 7th Framework Programme for Research. A major activity is Scientix (www.scientix.eu), coordinated by European Schoolnet (a non-profit established by ministries of education), which was created to facilitate sharing of know-how and best practices in inquiry-based science education across the European Union through its web platform, workshops, online courses and conferences. This project has grown in terms of content volume and teacher followers resulting in the European Commission prolonging its activities for a further three years until 2016.

Similarly, the inGenious initiative, a €8.3 million European Commission investment, supports school-industry exchange on STEM education and careers, to date reaching 6,000 European pupils through its school pilot projects. Teachers who join the inGenious Community have access to a broad range of face to face and on-line training activity, as well as opportunities to meet industry experts in a wide range of STEM topics from artificial intelligence to green chemistry.

Meanwhile in the Middle East and North Africa, the US National Academy of Sciences has tested a prototype summer institute for teachers from Algeria, Egypt, Jordan, Libya, and Yemen “to engage with effective, evidence-based teaching methods, develop curricular materials for use in their own classrooms” and become community leaders for ethical science teaching. The World Bank has financed a Yemeni distance learning initiative – targeting primary schools and North Africa, the US National Academy of Sciences has tested a prototype summer institute for teachers from Algeria, Egypt, Jordan, Libya, and Yemen “to engage with effective, evidence-based teaching methods, develop curricular materials for use in their own classrooms” and become community leaders for ethical science teaching. The World Bank has financed a Yemeni distance learning programme aimed at teachers from Algeria, Egypt, Jordan, Libya, and Yemen.

In Israel, the Ministry of Education has established a network of science centres to support schools. This new initiative – targeting primary schools particularly – offers training for teachers, as well as school activities in STEM organised by the centres. This allows primary classes to focus on more complex STEM topics than was formerly the case.

Such programs have become even more critical in the face of austerity measures, and the results of political instability, which have forced ministries of education to cut funding to formal CPD. To be effective, such programs need to be developed in close partnership with the formal education system, and either be flexible enough to be used in any country, or localised to fit the national curriculum.

Recommendations

Given that more progress is required, the previous recommendations still require further action. Specifically:

• More attention needs to be paid to STEM-specific competences to be acquired during curricular reform. Many recent reforms, although useful in terms of facilitating 21st century learning, do not pay specific attention to STEM specific competences and motivational issues (i.e. that students require more societal context to support their learning of STEM content). Future curricular reforms should try to integrate both agendas. Depending on the country and system in place, this may be via a centralised approach, but ideally, it should be at done at school level, integrating STEM in inquiry-based, problem-solving, collaborative projects.

• Teachers still require more access to training on innovative pedagogical methods such as inquiry-based and collaborative learning, and information on resources which already exist. Teachers must practice what they preach: collaboration between different subject teachers can help to demonstrate the value of collaboration to their students.

• Education systems need to accredit teacher training offered outside formal pre-service and CPD systems, so that teachers involved in e.g. MOOCs and company programs.
Engaging girls in STEM careers
Engaging girls in STEM careers

A major challenge in addressing student motivation for STEM studies and careers is the involvement of girls. Girls are relatively high achievers in STEM - they outperform boys in most countries - with particularly large gender differences in Jordan, Qatar, Dubai and Bulgaria according to the last PISA study. However, this high achievement fails to translate into interest in STEM and STEM careers. Girls do not see themselves as future engineers or scientists (outside the medical and biological sciences, where they are over-represented) and thus they choose different areas. This is particularly problematic in Western Europe and in areas such as maths, IT and engineering. In some Middle Eastern countries, more girls are studying these topics but do not go into jobs in the field. This contributes to a major part of the skills gap: if girls chose STEM careers as frequently as boys, much of the skills gap would be filled.

This theme was targeted by several recommendations in the previous white paper, as follows:

- Include topics and present them in ways that are more attractive to girls
- Use a broader set of role models.

Where are we now?
Since the last white paper, there is no new major statistical study on gender differences in attitudes to STEM across the region which can be used to measure any change accurately - in future, new data from the ROSE study can help here. So, at this stage we can only rely on anecdotal information. There are some indications that levels of girls’ interest in STEM are starting to change. For instance in the many countries, girls frequently report that they are interested in societal STEM issues (e.g. climate change) despite having a negative view of STEM jobs. Indeed, 2013 saw the first rise in the number of secondary students choosing technology studies at age 16 for more than 8 years in the UK. However this interest is not yet reflected in increased higher level, post-secondary study and career choices.

Gender was thus a strong and recurring theme amongst the STEM stakeholders present at the Intel Educator Academy EMEA. The benefits of encouraging more women into the STEM sector were widely accepted by delegates who called for greater and more co-ordinated efforts in this area at an early enough educational stage.

There are few major cross national initiatives apart from the “Science - it’s a girl thing” campaign run by the European Commission, which combined a promotional video with a series of events across Europe and will continue in 2014. The European Commission’s European Union Competition for Young Scientists (EUCYS) has also taken steps to increase female participation, encouraging for instance the involvement in the initiative of more science projects addressing social challenges, which tends to appeal more to girls.
Another European initiative is Girls’ Day, which takes place in the Netherlands, Germany and Austria among other member states. It recognises that the “gender gap is more likely caused by environmental influences such as parents, teachers and head teachers”. Girls’ Day focuses specifically on technology and ICT. Companies invite girls aged 12-15 for excursions. The real aim of the day is that the participating girls should get a broader and better concept of science, technology and ICT, and the opportunities available to them in these sectors. A similar program links the Middle East and the United States: the TechGirls initiative. The US Department of State brings girls from Algeria, Egypt, Jordan, Lebanon, Libya, Morocco, the Palestinian Territories, Tunisia, and Yemen to the United States for a three week exchange. They are invited to meet leading technology company role models and take part in a university-led tech youth camp.

At national level, targeted activities are more common. In the UK, workshops for educators on issues related to gender diversity in STEM education have been set up by Intel together with the non-profit association, Women in Science and Engineering. Intel France has been cooperating for some time with IMS Entreprendre, a French industry association that aims to combat gender stereotypes in STEM fields. IMS has developed a pedagogical toolkit which can be used by teachers and companies, and organises visits by company experts to schools to challenge stereotypes and break down barriers. There are plans to scale this up to a wider number of schools across Europe through partnerships with Corporate Social Responsibility (CSR) Europe, a European network of companies and national CSR associations.

Meanwhile, Towards Women in Science and Technology (TWIST) project, which took place from 2009-2012, led by Experimentarium from Copenhagen with the active participation of 6 science centres across Europe and Israel targeted young people, their teachers and parents as well as the general public. It focused on highlighting outdated stereotypes and prejudices on societal roles for men and women and career paths. The outcomes
included a set of recommendations for science educators in the formal and informal arenas. A handy tool to test unconscious bias is still available on the TwIST project website.

In the Netherlands, two projects, focused on sustainability topics - the “Clean Tech Battle” at the NEMO science centre in Amsterdam and the International Environment and Sustainability Olympiad (INESPO) - which reach beyond the typical STEM target group. The Clean Tech Battle combined science and technology knowledge with debate skills, where young people competed in teams to debate clean technology and its importance in the future. Over 800 students from secondary schools across the Netherlands took part, and prizes were awarded both to the best debating teams and the best individual debater. It brought together the science museum, the industry STEM education platform Jet-Net, ‘Natuur en Milieu Educatie’ (the association for teachers, educators and local government to promote environmental education) and the Dutch Debate Institute.

Taking the environment as a starting point is typically more engaging for girls than using more traditional engineering and technology topics. INESPO takes a similar approach of combining environmental issues with other scientific topics. The categories cover for instance, ‘environment and physics’, ‘environment and chemistry’ as well as social topics such as ‘environment and civics’. The jury of expert judges involved is also well balanced in terms of gender, compared to typical science and technology activities, which sends a positive message to participating students.

Meanwhile the German science fair, Jugend forscht (‘Youth research’), which is Europe’s largest with over 200,000 participants in its four decades of existence, has been a front runner in making special efforts to involve girls. For a number of years now, its marketing efforts specifically address girls’ concerns and they have established coaching to support girls with their candidacies.

Finally, teachers state that teaching diverse groups in an attractive way is a challenge. Textbooks and other teaching materials tend to show stereotyped images of scientists, with little representation of women or minorities. Again, few programs exist to support teachers in opening up their teaching to a more diverse target group, and text books are often slow to be adapted - particularly in smaller linguistic markets where publishers do not frequently release new editions. Future approaches to appeal to wider target groups should also look at these issues.

**Recommendations**

Although many efforts have been undertaken in the area of diversity, it remains a concern for numerous stakeholders. A number of key challenges remain to be addressed, and based on the debates, we can summarise the recommendations as follows:

- Efforts to stimulate a better gender balance in STEM education initiatives need to be better evaluated. Numerous measures exist, but few are really proven to have impact. Many are implemented prospectively, with insufficient consideration to assessing the impact.

- Use of diverse images in promotional materials and a range of role models in informal education is common - but important and must be continued. Care should be taken in event programs that equally diverse role models and speakers are engaged, to give students real life role models to be inspired by.

- There needs to be more focus on the role of teachers and teaching materials in encouraging diversity in STEM. Giving teachers training in how to appeal to diverse ranges of students is key. Publishers and other organisations providing teaching and learning materials must also take care to include diverse images of scientists and technologists.
Widening the impact of science fairs
Widening the impact of science fairs

Science fairs are a tried and tested model, with a strong positive impact on students engaged in them. Students are invited to carry out a student-driven research project on a topic of their choice - either individually or in teams. They are typically supported by teacher mentors through the process, and can reach out to experts in industry and universities to help them execute their research. Students involved in such activities display high levels of creativity to solve technical barriers: many design experiments which they can run in their own homes using low cost equipment, but which enable them to make important scientific conclusions. Science fairs in many countries have been in place for many years: Intel’s International Science and Engineering Fair is the world’s largest with more than 1,600 students from 70 countries competing face to face to win more than $4 million in prizes and scholarships.

The previous white paper recommended:

- Embed science fairs and festivals in the mainstream of school activity
- Science clubs and informal mechanisms to support teachers and students as they prepare projects for science fairs need to be better supported by formal education

Where are we now?

Embedding science fairs and festivals in the mainstream of school activity has progressed since the first Intel Educator Academy, thanks to some governmental initiatives. This has taken place entirely at national level as school decision making is the responsibility of national authorities. For instance, the Israeli education system is highly centralised, and is expanding participation in the national science fair as part of a program to increase the number of science graduates. The national science fair is operated by the Bloomfield Science Museum in Jerusalem, and partners with Intel ISEF at global level, and EUCYS at the European level. To ensure Israeli students have a chance to attend and achieve better results in the global finals, several actions have been put into place.

Firstly, to introduce the culture of science fairs to the Israeli school system, to the Israeli students and teachers, the Ministry of Education, with the Bloomfield science museum Jerusalem and Intel, initiated a new national program. All 6th and 9th grade students must prepare a science project as part of the curriculum, and present them in science fairs. The best projects go on to participate in regional finals, and ultimately in the national fair. 250,000 students took part last year in the program all over Israel. In addition - the Bloomfield Science Museum Jerusalem, as the national organiser of the young scientists competition in Israel,

A contributing factor to success in countries such as Finland and Canada, which record high levels of STEM interest and achievement according to PISA data, is better support for low achieving and average students, rather than only supporting the most gifted.
Widening the impact of science fairs

with the Ministry of Education’s pedagogical secretariat, initiated a program for 10th graders called “in the path of research”. The aim of the program is to introduce current research and young researchers (PhD students as role models) to excellent students at high school, to encourage them and support them in conducting their own research projects in academic institutions.

The German Youth Research competition (Jugend Forscht) has very close partnership with the Federal Ministry of Education and Research, as founding partner of the competition along with the magazine ‘Stern’, and five other relevant Ministries (e.g. Economy) offer their support. As Germany is a federal system, the regional governments are also very important in successful implementation in schools, and hence the event has also partnered with 16 state governments through the patronage of the Standing Conference of the Ministries of Education, which brings together all state level ministries.

In Ireland, the highly successful BT Young Scientist and Technology Exhibition is supported by the Department for Education, and has increased in impact year on year, with 40,000 people attending the last event. On the occasion of its fiftieth anniversary, the Taoiseach (Prime Minister) Enda Kennedy offered his congratulations to the event. It is seen as a cornerstone of the educational calendar in Ireland, and the organisers offer concrete advice to teachers on how to map the competition activities directly to curriculum objectives, so that it can be carried out in class with any science and technology student, rather than as a side-project for higher achievers.

Similarly, the Mawhiba programme in Saudi Arabia cooperates directly with the Ministry of Education, to organise local, regional and national science fairs for the whole of the kingdom since 2007. They have a specific focus on gifted children, to support their achievement at high levels in the international competitions, while also aiming to stimulate interest among all young people in STEM.

Slovakia also demonstrates a strong partnership between the Ministry of Education, Science, Research and Sport and the Young Scientists of Slovakia association for the organisation of the Scientia Pro Futuro competition. The prize-giving ceremony is the opening event in the national science and technology week, organised by the Ministry. This sends a strong message to teachers, to encourage them to engage their students in the activity.

Another type of science fair organised is the Dutch example, Jet Net Career Day, which has been running for ten years. The image that young people have of technology is not always clear and it even contradicts reality. As far as Jet-Net is concerned, the most effective way to promote interest in careers in technology is to let students experience it themselves. During the day, companies and institutions familiarise secondary school/pre-college students with professional practice in their organisation. Participating companies man interactive stands where they share their expertise and what they have to offer in terms of educational experiences. The aim, when students visit a stand, is to achieve a ratio of 20% listening and 80% doing. Students will build, program, test, calculate and measure for themselves. Each group of ten students is assigned a ‘career guide’ - a company employee or a student who has opted for a science-oriented education path. Students can ask this guide any questions they wish. Together, they visit the various stands to experience the versatility of technology and establish the link between academic theory and real-life practice. Many schools have integrated the Career Day into their curricula. Jet Net has
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monitored the impact over the last years, and has demonstrated a strong positive effect on students in terms of knowledge of the range of STEM professions and what it means to work in a technology company. JetNet is well embedded in the school system at national level and the events are over-subscribed.

In addition to embedding fairs in school activities, some key partnerships have been formed as a result of the last two Intel Educator Academies EMEA as well as the global Intel Educator Academies held in the USA.

For instance, EUCYS has now formed a strong partnership with Intel, with winners of EUCYS going on to the Intel Science and Engineering Fair finals in the USA. The joint organisation of the Bratislava Intel Educator Academy alongside the EUCYS programme is another good example, which gave higher visibility of the activities of the EUCYS fair to all the stakeholders attending the Educator Academy. This led to a wider exposure of the event to teachers from other networks involved, such as European Schoolnet’s teacher group attending as part of the Scientix and InGenious platforms for innovative STEM teaching and learning. The partnership between Intel and EUCYS continues in 2013 with a joint event in Prague.

A large number of the science fair attendees stated their fairs were directly linked with government through majority or partial funding and staffing. Yet, they are on the lookout for additional funding sources. Intel is backing many fairs across the EU and additional private sector sponsorship as well as media sponsorship is being solicited at national level. The event in Bratislava was very much a forum for the EU science fair managers (most EU fairs being represented at the event as well as fair representatives from South Africa, Middle East and South Africa) to compare their efforts and leverage each other’s experience. There was a recognised need among participants to raise their game when it comes to attracting and maintaining sponsors. Some successful examples in achieving good levels of sponsorship include: the Big Bang fair in the UK, sponsored by Siemens, Shell and BAE Systems among many others; in Ireland, the BT Young Scientist and Technology exhibition, supported by BT, Intel, Radio Television EIRE and more. The German ‘Jugend Forscht’ (Youth Research) event is particularly successful in attracting sponsorship and partnership with more than 150 corporate sponsors and partners at federal and regional level.

Levels of impact evaluation vary greatly across science fairs, from no evaluation methods at all to comparable year on year surveys. Across the fairs, however, there is no common evaluation approach which means that outcome data cannot be compared for different fairs. A new approach in EMEA, pioneered by Intel, is a shared approach to evaluation of science fairs, learning lessons from US science fair evaluation methodologies. A common tool is being established to measure results using common indicators – European Schoolnet will publish first results in autumn 2013. Science fairs will need to assess the usefulness of these indicators following the first published results.

Finally, one area which could be worth exploring in terms of building wider engagement, but so far has not been done to a great extent is the engagement of young people or other stakeholders who do not typically participate in fairs to play an advisory role. It can help fairs understand why they do not participate, and design new strategies accordingly.

Recommendations

- Reach out to wider groups of partners at national and regional level to increase impact and visibility. STEM industry is keen to support STEM fairs in many countries, and are insufficiently involved in others.
- Consider involving media partners as well as the usual associations and government partners. Government partners need to continue to be pushed to further integrate fairs with schooling, although some countries are successful.
- Youth panels offer a valuable “reality check” to ensure approaches really suit their needs. Engage where possible with groups who do not usually participate: their support in advisory roles may help to widen participation.
- Ensure continued sharing of impact assessment methods, data and strategies for evaluation. Share best practice and lessons learned in increasing impact on the basis of these common benchmarks.
Building and sustaining effective partnerships
Building and sustaining effective partnerships

The UN Global Compact Leaders’ Summit in 2013 underlined the continuing importance of multi-stakeholder partnerships in tackling societal and environmental challenges as a whole, while that “human capacities” (i.e. education) remain a key priority area post-2015. The associated report noted that education is an urgent and highly impactful area to focus on, and that specifically partnerships between business and societal actors should aim to prepare young people for their future jobs - 25% of business leaders the UN surveyed agreed that education should be the top priority. This call to action echoes recommendations from the previous white paper, to establish and enhance sustainable multi-stakeholder partnerships to combine forces to tackle the challenges of STEM education.

More specifically, it was suggested to:

• Bring together government (all relevant national ministries, and authorities with responsibilities from national to local level), industry, research, communities, associations and science communication stakeholders

• Link explicitly such initiatives to achievement in both traditional STEM indicators and more innovative competence-led 21st century skill sets.

Where are we now?

Some countries have made advances at national level in establishing new forms of partnership between government and other stakeholders, with a link to clearly measurable targets. Little statistical data exists on such partnerships, so in this section we rely on specific illustrative cases.

At international level, the European Commission - as well as industry and national governments - continue to play a key role in stimulating existing long term partnerships to address STEM education issues, as well as founding new ones. The InGenious platform, co-funded by the European Commission and by industry - continues to grow with a substantial number of new partners since the first Intel Educator Academy, now comprising 41 partners – including companies and STEM education stakeholders. There are strong indications that the European Commission will continue to fund collaboration between education and science stakeholders in the Responsible Research and Innovation action of the forthcoming Horizon 2020 research programme, while the new Erasmus+ programme for education will include a number of “sector skills alliances”, which aim to better align the worlds of education and work, in a number of fields.

More specifically focusing on technology, the Grand Coalition for Digital Jobs, launched by Vice President Neelie Kroes, brings together numerous stakeholders from education and training, industry and associations to address the whole talent pipeline from young people to
older workers in acquiring more digital skills for professions. Like InGenious, this Grand Coalition will be funded in part by the European Commission, with co-funding from the remaining stakeholders.

At national level, similar partnerships are key. For instance, in Israel, the previously mentioned 'We are the future' program aims to increase the number of students graduating with high level STEM scores, bringing together the Ministry of Education, Intel, NGOs and science centres. Similarly, key organisations such as the Trump Foundation and the Israeli Centre for Civil Society are supporting partnerships between business, museums, and other stakeholders to improve STEM education.

The Netherlands is a particularly good example where such partnerships have been high priority over a long period of time - Jet-Net, a partnership at national level celebrated its 10th year of activity in 2012. There are similar smaller partnerships organised around different scientific topics; for instance the NEMO science centre in Amsterdam partners with industry, schools, government and science communicators for its programs. The aforementioned Techniekpact provides a strong framework for partnerships in the next years.

Through the inGenious platform, Danish Science Factory and the European Round Table of Industrialists are leading a task force to create a toolkit to aid countries in the establishment of national STEM platforms, drawing on successful approaches from various countries. Interaction between education and industry is one of the key elements to change the dynamics at national level. Also, since the first Intel Educator Academy, Jet-Net is now working more closely with other countries such as Denmark, Estonia and Portugal to share lessons learned and experience across borders. InGenious has also published a code of conduct, to help new partnerships to work together in a clear and transparent way. International groups such as InGenious can facilitate this kind of sharing of approaches.

Such multi-stakeholder models seem to continue to be the best option for sustainable partnerships in the EMEA region. Given the sustained period of economic difficulty, they facilitate longer term cooperation and action despite individual players needing to vary their own commitment over time. Formal consortia tend to lend themselves to more sustainable approaches too: a contractual relationship commits partners better than a purely informal
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Building and sustaining effective partnerships

approach – but must be set up for longer than a typical EU funded project. It ensures that partners are committed over a long period, rather than short term actions which tend to be less successful. However their distribution is still patchy, with some countries taking up or considering such partnerships at national scale, involving many stakeholders, while other countries still have only small, less sustainable and fragmented approaches.

Although the previous recommendation of linking initiatives to achievement levels and motivation levels in STEM is an important one, it is often difficult from both a budgetary and a competence perspective to effectively measure these indicators within existing consortia. Current international research such as PISA tends to also give data on more traditional STEM indicators (i.e. knowledge of specific topics) rather than ones based on a more innovative approach. Multi-stakeholder partnerships could benefit from a stronger shared research methodology to benchmark results across different countries over the long term, while also monitoring shorter term impact indicators such as changes in motivation/interest which can be measured within a short timeframe.

Recommendations

- More countries need to explore the feasibility and set up of national multi-stakeholder STEM platforms. Bringing together the key players from every angle: Ministries of Education, schools, businesses, science centres and NGOs brings fruitful results.

- National and local authorities can learn from successful models in other countries to inspire a localised approach in their own context, by engaging with experienced organisations abroad, or learning more through publications produced by them.

- European and other international funding programs need to continue to support the sharing of knowledge and good practice in this field. They should encourage cooperation on a long term, not only in short term consortia for projects.

- Research methodologies for benchmarking success of STEM education partnerships need to be enhanced, and shared across partnerships. Using common approaches will allow for better comparison of results and impact. International surveys also need to include more innovative indicators of STEM achievement, rather than mastery of content.
Conclusions
Conclusions

Much progress has been made in addressing STEM education challenges in the EMEA region, and new partnerships have been forged since the organisation of the first two Intel Educator Academies.

Most of the areas identified – STEM teaching and curriculum, diversity, widening impact of STEM fairs - remain key priorities; education systems do not change quickly. The picture is changing slowly but surely and the specific emphasis within these areas is changing to meet current and future needs. Our fourth area of interest - multi-stakeholder partnerships - is a transversal tool to support all previous priorities.

The importance of multi-stakeholder partnerships to tackle challenges across these areas seems to be well recognised, and increasing numbers of such partnerships are being established at national and international level.

Based on the discussions in the previous sections of this white paper, we conclude by summarising the recommendations.

Continue to prioritise enhanced STEM curricula, pedagogy and teacher support by:

- Ensuring that STEM competencies and specific needs in terms of motivation and contextual knowledge are better taken account in curricular reforms both at the school level as well as nationally.
- Giving teachers more access to training, including working with colleagues from other disciplines, particularly in new forms of pedagogy and to give them better knowledge of resources they can use to support their teaching.

Reach out and engage marginalised groups, through:

- Better recognising teacher training they are engaged in outside of the formal teacher training systems.
- Evaluation of the impact of efforts to improve the gender balance in STEM studies and STEM activities, so as to better understand which methods are really worthwhile.
- Monitoring of emerging issues in disengagement, to pre-empt future diversity challenges.
- Portraying a diverse image of scientists and technologists in events, publications and learning materials, and support teachers in sharing this view.
- Widening the focus of diversity measures to better tackle those from disadvantaged backgrounds.

Engage more students in STEM fairs by:

- Increasing the number and range of partners supporting STEM fairs at national level, including government, media, associations and industry in all countries.
- Enhancing the organisational approach of STEM fairs to better tackle multilingualism, integrate alumni and youth panels.

Engaging youth panels to enhance activities, and give a “reality check” on what works for them.

- Sharing lessons learned, common impact indicators and strategies to benchmark and compare achievements between fairs.
- Strengthening multi-stakeholder partnerships committed to work together over the long term.
- Encouraging cooperation with science centres and business as partners to support STEM education reforms, teacher training, STEM fairs, and other innovative approaches.
- Ensuring sharing of data and lessons learned on the results of partnerships through common indicators, and measuring traditional as well as non-traditional indicators of STEM motivation and achievement.

Governments, businesses, NGOs and science fairs need to continue to prioritise innovative STEM education in their strategies, learning from past successes and failures, and refining their approaches to have a real impact in the EMEA region. It is clear that there is potential to reverse the decline in interest and achievement in STEM education, if we have the courage and commitment to put in place the measures to address it.
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