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LINKS

Learning
from
Innovation and Networking
in STEM

Coordinator

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Introduction

During the last few decades it has been commonly understood that students´ interest in science subjects has decreased. This has become problematic, for example, for industries that need employees with sufficient scientific knowledge and skills. The connections between science subjects and knowledge of industries, with different professions and products, can increase students´ interests, positive attitudes and achievement. Therefore, it is essential for the teachers to introduce industry-based examples and experiences to their teaching, at early stages of education. In France, engineering schools report an alarming lack of students in scientific fields, especially in IT. While 35,000 were recruited in 2017, 50,000 would be needed in 2022.

There are many ways to introduce industry-based examples to teaching. For example, field trips are beneficiary and motivating for students although they are mostly done within museums, botanical gardens or scientific centres and less to visit industries. Industry-based collaboration can be beneficial for the whole community around school. It can also be motivating for students, teachers and parents. In order to promote interactions between the world of industry and the world of education, it is crucial to develop the abilities of teachers to create and manage such interactions, either pre-service or within service. In this toolkit, we provide inspiring examples from 5 different countries to showcase good practice. In chapter 1, the current situation in teacher education in Austria, Finland, France, England and Italy is presented. Chapter 2 details insights and examples of school-industry collaboration. In chapter 3, conclusions and suggestions for the fruitful collaboration are made.

1

Teacher education and industry-based issues in Austria, England, Finland, France and Italy

1.1 Austria

Elementary educators are trained in a 5-year upper secondary school, in-service training for this target group is offered at Universities for Teacher Education and in training courses organized by regional municipalities. Primary teachers are trained in colleges (or applied universities) for teacher education. There are overall 13 applied universities for teacher training in Austria in 2018, among which nine are run by the state and four are privately run by the catholic church. The curriculum for teacher education was recently revised (2016). Now the duration of the pre-service teacher training has been extended to four years (formerly its duration was three years). In-service teacher training courses are also offered by the universities of teacher education, often in collaboration with non-formal educational institutions like Science Centres.

Starting with the academic year 2016/17, the "New Teacher Training" clusters were launched in Austria. Institutions that engage within the fields of pre-service and in-service teacher training now form four regional clusters spanning all over Austria. Within the four regional clusters, the curriculum is jointly developed and should correspond to the professional, subject-related, as well as to the educational and practical requirements of regional schools. These clusters provide academic education for all teachers of «Secondary Education» at General Compulsory Schools (APS), Grammar Schools (AHS), and Vocational Secondary Schools (BMHS). Students can thus choose from a wide range of subjects and courses and, together with experts in the fields of science, subject didactics, and educational science, as well as with practitioners in schools, prepare themselves for their future profession as teachers. Until now the in-service training of teachers within compulsory school is regulated via the law for teachers in their respective province and recommends in-service further education with up to 15 hours per year. Grammar school teachers as well as teachers within Vocational Secondary schools respond to the federal law with unspecified requirements when it comes to the compulsory duration of activities within this field. Thus, they tend to participate in in-service further education less than their colleagues in compulsory schools as studies like Mayer and Müller (2010) show. (Source https://www.bifie.at/buch/1179/2 Download 30.11.2016).

The Austrian school law prescribes career and educational counselling for all teachers. The coordination of career guidance measures is a task of the head of the school. This law requests that every school has to have a teacher who is qualified for the coordination of career counselling. Advanced training courses are offered by Universities for Teacher Education:

- training course for the coordination of career counselling (3 semesters);
- training course for pupil- and education counselling (4-5 semesters).

(www.schulpsychologie.at/bildungsinformation)

Furthermore, there are individually organized projects and initiatives which are mostly made up by companies or the Austrian federations of industry. Here are some examples:

- "Faszination Technik" (fascinating technics) which is an initiative rising from a noticed lack of engineers. Its aim is to engage pupils in STEM fields of application and in technical (vocational) training. This initiative supports teachers of all levels and school types in practical orientated teaching. Furthermore, there is a cooperation called "Cooperation School-Industry". They offer teacher-workshops starting with offering toolkits for company visits for the whole class. (https://www.faszination-technik.at /)
- The Federation of Austrian industries (IV) is engaged in educational policies in different ways. In Styria, the federation of Austrian industries implemented a project management person who is responsible for the cooperation of schools and industries. They created this job due to low interest of young people in STEM-fields. The IV stresses that companies require people with special skills, resources and knowledge due to special demands of the Styrian. IV's goal is to better integrate work place knowledge within school education. They provide a platform to present industries to schools, they offer support in linking industries and teachers, during events, workshops, etc. (https://steiermark.iv.at/de/themen/bildung-und-gesellschaft; https://www.dieindustrie.at/die-industrie-im-unterricht/fortbildungen/)

In the curriculum (2012, https://bildung.bmbwf.gv.at/schulen/bo/rg/bolp.html) exists a paragraph for obligatory "career guidance classes". These have to be integrated in several subjects but pursue autonomous targets. Career guidance classes are seeking to heighten decision-making abilities of pupils with the aim of strengthening self-competences and knowledge about the professional world through developing competences in subject matters and methodological skills. Career guidance should also contribute to reviewing traditional positions and biased opinions of professions. The curriculum proposes activities like talks with class, role plays, working in groups, autonomous work and different opportunities like explorations of schools, companies and professions, professional days, visits to career fairs. The curriculum also reminds teachers that these activities require preparation and follow-up sessions in class.

- Aims of career guidance classes for pupils in different grades:
- explore and reflect on own wishes, interests and tendencies as well as getting aware of abilities and skills;
- getting to know professions/work places in its varied importance for people;
- gender issues connected to different choices of professions and pay;
- including parents in vocational decisions;
- building strategy for the own career, etc. (https://bildung.bmbwf.gv.at/schulen/unterricht/ba/ahs19_794.pdf?61ebv3)

1.2 England

It has been identified that in the UK there is a severe lack of people entering the job market with the skills needed for a stem career (a projected shortfall of 1.8 million engineers by 2025). 82% of secondary school teachers felt they lacked the necessary knowledge to offer careers advice to their students. Following on from this, in December 2017, the UK government published the Careers Strategy which was based on the Gatsby Benchmarks for good careers teaching[1]. These benchmarks made school specific guidance for engaging with employers from an early age and throughout a student's school career. There was also specific STEM guidance for positive engagement with STEM employers. In January 2018, the Department for Education updated their guidance and made the Gatsby benchmarks statutory for all secondary schools[2]. Importantly every year from the age of 11, pupils must participate in one meaningful encounter with an employer. Also, by the age of 18 they should have had two experiences of workplaces.

There are various routes into teaching in the UK and all lead to qualified teacher status. For primary teachers, there is a university only route over 4 years where the trainees gain a degree in teaching. For both primary and secondary teaching, there is the option of completing a separate degree in a school subject and then completing a Post Graduate Certificate in Education of one year's duration. These can be completed either at a University or within a School Centered Initial Teacher Training centre. Recently several schools have developed their own training programs and have become teaching schools, where teachers train at the school and complete their PGCE in this school. There is currently no expectation that during initial teacher training, trainees will be exposed to industry or industrial careers advice.

In Secondary school, there is a lot of specialist teaching of subjects but there may be little application for how this might relate to future work options. Assessed practicals dominate science teaching and careers discussions can often be left to the careers teacher or citizenship lessons.

In secondary school, students usually spend 2 weeks attending a work experience placement; this is usually chosen by the pupil and can be in any field of interest to the pupil. A recent study by Kings College London under the Enterprising Science banner focused on children's science capital. This was defined as how much science young people were exposed and had access to. It encompassed eight dimensions that developed a child's science capital[3].

Many schools have adopted this approach with their classes and are seeing the benefits of developing their students' science capital alongside the more curriculum based activities of the school. In the primary years, topics such as people who help us, are taught to the very young. Here they learn about different jobs and what things these people do in their jobs. The curriculum mentions famous scientists or engineers but mainly about their discoveries or work, not how they got to where they got. Schools often organize visits to industry. Schools set this up a link to support particular areas of their curriculum, for example: a visit to a power station when studying electricity. The industry prepares teaching resources to support the visit both whilst on site and post visit back in the classroom.

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment _ data/file/664319/Careers _ strategy.pdf

[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment _ data/file/748474/181008 _ schools _ statutory _ guidance _ final.pdf

[3] https://www.kcl.ac.uk/sspp/departments/education/research/Research-Centres/cppr/Research/currentpro/Enterprising-Science/01Science-Capital.aspx

1.3 Finland

Generally, teachers with chemistry, mathematics or physics as a major subject at the Master´s level will be qualified to teach at all school levels: mandatory comprehensive school (grades 1-9), voluntary vocational or upper secondary school (grades 10-12) and at the higher level, except for university. The working-life studies during teacher education are voluntary. *Science and Mathematics in Society* (5 ECTS) is included in pre-service teachers' voluntary working life studies in the new *Degree Program for Subject Teachers in Mathematics, Physics and Chemistry* at the University of Helsinki. The school-industry collaboration course in Helsinki is based on a previous research and the new core curriculum. In the course, pre-service teachers practice collaboration with the industry members and the local school and make teaching material. The focus of the course is in the local companies and institutes in order, to save schools´ resources like time and money. There is also a voluntary online course which is based on the university course. The course is implemented for interested pre-service and in-service teachers and teacher educators as a part of LUMA Finland development program. Previously, there have been partners from the Economic Information Office TAT, Finnish Chemical Industry, the field of marketing and forestry, Me & My City and from several companies. The bigger companies and the associations which are representing the interests of companies have also school-industry cooperation of their own.

The National Core Curriculum for Basic Education in Finland has some suggestions to enhance students´ interests, skills and knowledge about working life. Schoolwork could be organized in a way that students could be able to have examples as well as authentic experiences about working life and entrepreneurship. That might be accomplished, for example, by getting familiar with local companies and their vocations and products. The industry-based experiences can differ from smaller tasks to bigger projects. There is also an obligatory one-week internship in 8th and 9th grades where cooperation skills and workplace behavior are practiced. The aim is that students understand the importance of working-life knowledge and skills in order to be responsible and active citizens in their future. Activity as citizens, entrepreneurship and working life skills are also main goals in the National Core Curriculum for Upper Secondary Education. The goals are similar to those in general education but more profound. The vocational upper secondary education has different units with different national requirements. The school-industry cooperation including internships are obligatory and essential in all units.

There is a moderate amount of school-industry cooperation during basic education. Students seldom make visits to the companies although they are the most preferred teaching methods. School-industry cooperation and visits are also preferred by teachers, but they do not have enough time and other resources to implement them to teaching. The cooperation can be planned and implemented by the teacher or with the cooperation of the university or different associations. There are many company-representing associations which work with schools in all levels. The bigger companies have usually more activities for schools than smaller, local companies.

1.4 France

In France, most primary and secondary school teachers are state employees recruited through the process of competitive examinations. The recruitment competition takes place during the first year of a master's degree in teaching, education and training professions. The second year of the Masters combines university teaching contents, a practical internship in a school as a teacher and the writing of a thesis. Except for the recruitment of vocational school teachers, issues of the school-industry relationship are generally not part of the pre-service training content, so that teachers in primary schools, middle schools and general and technological high schools enter the profession untrained in this subject. The French Ministry of Education makes available to its one million civil servants a catalog of over 5,000 short training programs partnered with the business world, called CERPEP[4]. Those training programs consist of internships or visits in public or private organizations. They are aimed at education staff, as well as non-education staff (management, inspection, guidance counselors). They allow their trainees to:

- get to know better social issues or jobs related to a specific field;
- bring guidance to their students ("PARCOURS AVENIR");
- deepen their field knowledge;
- engage in interdisciplinary work;

benefit from support for management positions (recruitment-based courses, management etc.). However, few science teachers benefit those programs, especially if they work in primary school. As a matter of fact, they do not necessarily see the interest of them for advancing their career or improving their teaching.

Thanks to the «PARCOURS AVENIR»[5] taking place throughout secondary school (from year 6 to year 12), pupils develop a strong ability to select the course of study that fits them best. «PARCOURS AVENIR» allows them to:

- understand the economic and professional world;
- broaden their range of conceivable jobs and trainings;
- develop their sense of commitment and initiative;
- create their own educational and professional project.

Any student can benefit from it, regardless of its study path (general, technical or professional).

Partnerships with the economic, social and professional spheres make it possible to reinforce knowledge and skills by:

- discovery actions (company visits, conventions, conferences and debates);
- awareness-raising or training speeches (by business leaders or professionals in classrooms;
- in the context of educational projects);
- actions in the workplace (classes in the office, internships);
- supervised projects (mini-companies, job reports).

During his schooling, the student must at least have visited a company, met a professional (example: coming from a professional from a sector in the establishment to talk about his job), participated in a project (example: mini-company project), and carried out an internship in grade 9.

[4] http://eduscol.education.fr/pid31668/l-offre-stages-courts-cerpep.html
[5] http://www.education.gouv.fr/cid83948/le-parcours-avenir.html

1.5 Italy

In Italy, teachers with Natural Science, Biology and Chemistry degree are qualified to teach Natural Science at upper secondary school (14-19 years old), while teachers also with mathematics or physics degree can teach Mathematics and science at lower secondary school (11-14 years old). For future teachers, there is a structured pathway which drives the possibility of being a teacher. In the last few years, many different compulsory qualification processes occurred and right now a new one seems to be defined. The training is completely different for the tenured teachers; right now, it is mostly based on teachers' own needs and desire of updating their knowledge. Since the last school reform (2015), 25 hours teacher training per year has been introduced, but this is not compulsory, thus updating still voluntary.

Concerning the cooperation between schools and industry in Italy, there is a long tradition for vocational schools or technical ones, where the students have to spend in an industry a minimum of 210 hours, in an industry, in the last three years of the 5 of school. Since 2018, the high school students have to spend a minimum of 90 hours of work experiences before finishing school. This means that 1.5 million Italian students are involved in this educational pathway. To make it possible, each school has to build a well-structured network with the local industry which can host their students. The type of industry involved is usually related to the type of school, with the idea of making these hours as useful as possible both for students and for the industry where students may work at the end of the school. This type of "school-work alternation" is an innovative teaching method, which helps to consolidate the knowledge acquired at school through practical experience and drives the students to test their attitudes outside of school; the idea is to enrich students' training and to orientate their future studies.

2

Fostering a fruitful collaboration between schools and industries

It is thought best practice that each pupil should have at least 3 opportunities to participate in an industry-based cooperation during their school-career from elementary level to high school level. In that way, students have increased knowledge of the products, services and careers within science/STEM subjects. In addition, both teachers and students should have opportunities to experience different workplaces. There are several questions such as - how to reach all the teachers in the teacher training and in that way, reach as many pupils as possible? There are many options of how school-company collaboration could be developed depending on the needs of teachers and students. For example:

1. The visitor/ambassador from the industry can visit the school or they contact each other by video presentations, etc.;
2. The teacher/teachers visit industry for professional development;
3. The teacher and the class make a visit to the industry;
4. The school has an industry-based project with a final event with representatives from the industry.

2.1 How to start?

Before planning any further, you can ask the following questions:

- What is the purpose of collaboration?
- What are your students supposed to learn?
- How is the collaboration linked to curriculum?
- Is it suitable for all students (the possibility to differentiate)?
- Do I have money for the cooperation? (For example: if the answer is no, pick a company near the school/if yes, there is a possibility to travel.)
- Do I have an opportunity to collaborate with other teachers/schools?
- Can I make only one visit?
- Can it be a longer project? (If no, a teacher could have one or two lessons, etc.)
- Can I take the whole class to the visit? (If no, there might be a possibility to divide the class in smaller groups.)
- Do I have enough subject knowledge about the topics in the lesson/project? (If no, ask another subject teacher or some other specialist to join your lesson/project and share your expertise and resources.)
- Can the company representative visit the school?

Following issues may be also important to consider:

- If you are uncertain about the company that you would like to visit, ask professional advice. Maybe a scientist from the university or from the company itself could provide some background information before the visit?
- If not all school teachers can participate to school-company collaboration, each school could have 1 to 2 teachers who are devoted to this collaboration, know about the way to interact with employers, are eventually trained onwards, etc.
- Be aware of the security issues of the company and make a code of conduct if needed.

2.2 Successful ideas for the collaboration

There are several options how to proceed. For example, you can go to the company then implement a project/lesson at your own school, take your class to the company or invite a company representative to your school. You can choose one of the following ideas and apply it for your own school.

2.2.1 Austria

IMST REGIONAL NETWORKS PROJECTS WITH INDUSTRY

In each region projects include the following stages:

- Preparation and planning of the project of cooperation with industry
- Project proposal/planning of classroom lessons by teachers
- Opening presentation – kick off at the beginning of school year
- Industry and researcher's introduction on specific topic
- Start of project in school
- Workshop for teachers and didactical accompaniment
- Arranging lessons
- Visit of industry
- Report and Final presentation on network day.

BOX 1

"Papier macht Schule" - Paper makes Schools

In the long-lasting cooperation between paper industry in Styria with the Regional Networks in Styria, different levels of cooperation and offers are proposed:

1. experimental kit in combination with attending workshops;
2. financial support of school projects related with continuous didactical supervision and reporting;
3. dissemination of material related to implementation of a project.

All forms of cooperations and projects are didactically supported by experts, who are teachers and teacher-trainers, of the regional networks of IMST. There are also offers for every school type and level. All projects are long-term oriented, spanning about one school year. Upon completion, projects are presented in the form of a "poster rap" which includes a 1-minute presentation, and the exhibition of their poster in a marketplace on the yearly IMST network day (see photos). During this event, representatives of industry and university researchers are also involved and give lectures about cutting edge topics. The event also provides room to learn about projects, discuss topics and exchange ideas with peers.

This successful initiative of "network day" from Styria is already expanding in the federal states of Lower Austria, Upper Austria, Burgenland and Carinthia.

2.2.2 England

THE STEM AMBASSADOR PROGRAMME

STEM ambassadors are all professionals working within a STEM field. This is a programme run by STEM Learning Ltd and at present has over 30,000 ambassadors registered from 2,500 different employers. They work as volunteers to support teachers in school with varied activities. This could be a careers day, project or area of learning, inspirational activity or they can work with teachers to plan their curriculum and update their subject knowledge and careers knowledge.

The main steps through the programme are:

- Teachers decide on an area of the curriculum or careers training they would like support with.
- They then contact the programme or individual industry they are interested in and request support.
- The STEM ambassador then contacts the teacher and they joint plan an activity that meets the requirements of the project.
- The STEM ambassador then attends the school and delivers either a workshop/ talk/ careers event/ planning guidance with the students and/or teaching staff.
- After the event, the teacher provides feedback to the ambassador so that the event can be evaluated.
- Links are then hopefully developed with the industry and school.

BOX 2

An example of successful work completed at a Primary School level. Polar Explorer Programme

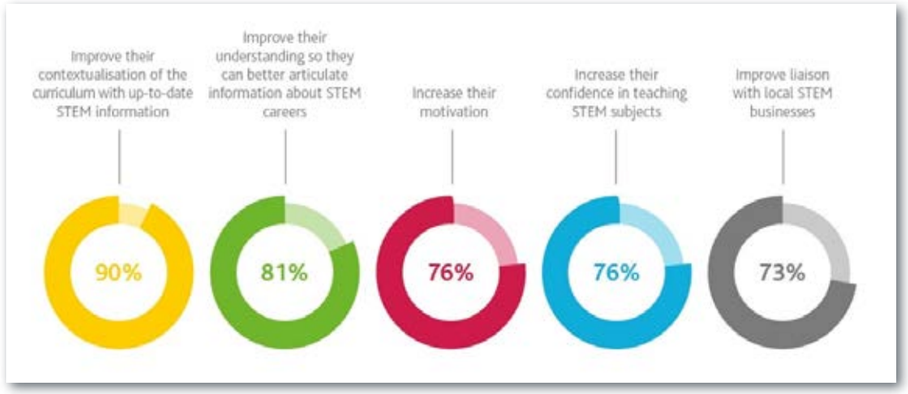
STEM Learning created a resource for primary schools based on the launch of the Polar Research vessel the RRS Sir David Attenborough and the work of scientists working within the polar regions. This was named the Polar Explorer Project. Schools applied to be part of the project and were supported in delivery by a 'Polar' ambassador' (a STEM ambassador with a particular interest in either ship building or Polar Science).

The ambassador worked closely with the school to deliver both child facing activities and develop teacher subject knowledge. Examples of activities included: building polar research vessels, conducting ice breaker investigations, planning a diet for a polar explorer, researching the animals that make their homes in the Polar Regions and investigating the effects of global warming and pollution at the poles. Schools were also invited to Skype call a polar scientist and learn more about their work. The project was supported by: BEIS (Department for Business, Energy and Industrial Strategy), with additional support from BAS (British Antarctic Survey), NERC (The Natural Environmental Research Council) and Digital Explorer.

Impact of the program:

- 95% increase in confidence in teaching STEM subjects;
- 98% increased enthusiasm and motivation for teaching;
- 98% agree that the program has raised the profile of STEM subjects;
- Increased cross-curricular teaching and increased confidence when teaching the working scientifically aspects of the National Curriculum;
- 90% teachers stated an increase in pupil attainment in STEM subjects;
- Pupils' enjoyment and engagement in STEM subject lessons has increased;
- 87% stated an increase in pupils' STEM career aspirations.

Fig.1 Impact of STEM Ambassadors on teachers



THE STEM INSIGHT PROGRAMME[6]

In this programme, teachers are placed in an industry or university for a week-long placement. They learn about the industry and the various routes into this field, spend time with apprentices and discover what they studied at school and how this can be shared with students. They can ask questions of the employees and set up activities with them which their students can then complete in school. Teachers set up links with the industry and are then encouraged to invite the industry into school for careers events, particular projects, etc. School visits are encouraged so that the students can see what happens in industry and how what they are learning in school has implications for the wider world of work. This program has been very successful within Secondary schools and has now been opened for Primary school teachers to help them with careers provision from an earlier age.

BOX 3

Alice at Caterpillar

The following is an example of a successful STEM Insight placement and impact when the teacher returned to their school.

The teacher, Alice, a secondary school teacher, attended 10 days of placement at Caterpillar, a world leading manufacturer of machinery and engines which employs more than 10,000 people in the UK. Alice identified a need to develop the confidence, knowledge and quality of delivery of STEM in her school. She was particularly interested in supporting effective and up-to-date careers advice. During the placement, she learnt firsthand what skills are needed in the variety of roles at Caterpillar, also about the technology and processes used. She witnessed meetings, got involved in problem solving tasks and even operated some giant machines. The placement challenged some commonly held views about whether there are types of people suitable for STEM careers. It's not just for the academics. You need to be motivated, have a questioning mindset, be a problem solver and be creative. She also discovered that the world of manufacturing was not the dirty, noisy environment with people in oily overalls she imagined.

On return to school, Alice has implemented many programs impacting over 400 students. She:

- developed curriculum resources with a focus on careers;
- organised a careers and women in STEM event;
- arranged a visit to Caterpillar for students;
- supported subject information evenings where entry into STEM careers was prominent;
- supported work placements for students into STEM industries;
- updated STEM schemes of work with examples taken from placement.

«Now, I am equipped with up-to-date knowledge, real examples and experiences, as well as strong industry links that I can use to benefit the whole school.» Alice

INDUSTRIAL PARTNERSHIPS

Recently, STEM Learning has become involved in a number of industry sponsored school partnerships. Here, the industry provides funding to a group of up to eight schools and they work together over a two-year period to develop an area that they perceive is a weakness for the partnership of schools. For example: engaging girls in post 16 science. They receive CPD from STEM le arning and engage with a variety of projects together to inspire the students to engage more with STEM subjects. The industry may also support with visits and resources linked to their project.

2.2.3 Finland

UTILISING THE POTENTIAL OF SMALLER COMPANIES

- First, pre- or in-service teachers have a few lessons about the theory behind school-company collaboration. The most fruitful visit/collaboration has 3 parts: tasks before the visit, during the visit and after the visit. The aim is that student teachers really learn about the products, services and careers and are able to connect the subject knowledge and authentic examples from real life.
- Since the company is near school, less money and time is spent. There is a vast amount of possibilities what careers and subjects can be found nearby.
- A teacher contacts the company representative and makes a first visit by her/himself. It is very important to have a proper discussion where ideas and hopes can be shared.
- Before the visit, pupils make some excercises such as getting more information from the company, make questions (what to ask from company representatives), familiarize themselves to the environmental issues concerning the products, etc.
- During the visit, pupils get more knowledge about the company, interview the employees, prepare something simple, for example in the laboratory, solve a «problem» that is made for them by the company representatives, etc.
- After the visit, there can be discussions, some STEM related excercises, etc.6

2.2.4 France

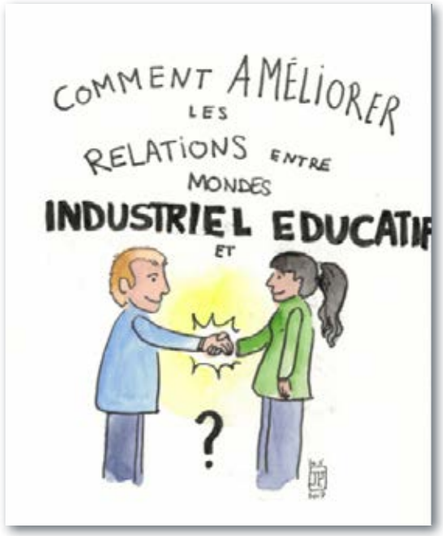
THE HOUSES FOR SCIENCE

At a time when school-company interactions are still marginal in France, the 10 “Maisons pour la science” (Houses for Science) have initiated partnerships to communicate with teachers on scientific and technical professions, business science and industrial processes. Set up in Universities, the Houses for Science find through local companies, a way to discover science and technology, especially innovation, but also to link with the corporate world and civil society.

To publicise its action to the local industry and develop new partnerships with companies, each House for Science can organise conferences and seminars dedicated to industrial partnerships.

For instance, in May 2017, a meeting day was held to introduce local businesses to the activities of the House for Science in the region Alpes-Dauphiné, in order to build new partnerships7. This event, repeated in April 20188, opens new opportunities to build successful relationships for projects that will benefit teachers.

Houses for Science can also solicit meetings with business foundations or local entrepreneurs to communicate about their actions in order to build first a common culture, then joint projects.



* How can we improve the relationships between industry and education?

In all cases, the Houses for Science develop a business-specific pitch. Indeed, teachers, rector’s offices, local authorities and businesses are not being addressed the same way, for these actors have different sensitivities and concerns. To answer this diversity, the creation in the Houses of «Partners Committees” has been very useful. During these committee meetings, the House for Science can:

- report to the various partners of the activities of the House;
- value those who are already involved;
- encourage others to mobilise for the teaching of science and technology.

[6] More research of the subject Pre-service teachers´beliefs about the benefits and challenges of STSE based school-industry collaboration and practices in science education: http://oaji.net/articles/2017/987-1544860568.pdf

[7] https://www.echosciences-grenoble.fr/articles/seminaire-maison-pour-la-science-2017-rencontres-entre-les-mondes-industriel-educatif

[8] http://www.maisons-pour-la-science.org/sites/default/files/upload/CP _ 2019.04.11 _ Seminaire%20MPLS _ VF.pdf

Among all possible ways of partnership, sponsorship is the most widespread and fiscally profitable for companies. There are three types of sponsorships:

- Skills sponsorship (participation of company employees in professional development actions, company visits, etc.);
- Donation of material and equipment;
- Financial sponsorship to organise events, pay for travel, cover running costs, etc.

The mutual benefits of such partnerships are numerous.

For the benefit of the House for Science, companies contribute to the development of scientific, technical and even didactic contents of training programs for teachers (for instance: materials in housing: needs for innovation, energy challenges, food preservation, etc.). Some of them bridge the gap between theoretical research and practical applications. They host teachers in places they usually never have access to. They help teachers to advise their students in their career path by showing the diversity of scientific and technical careers as well as the training paths that lead to them. They provide opportunities for internships or training for trainers or teachers themselves. All these contributions are tantamount to skills sponsorship because they mobilise the employers’ teams. Companies can also contribute to the financing of a House for Science, as part of sponsorship.

BOX 3

Co-building and co-delivering a training session with a company: the example of Saint-Gobain

Saint-Gobain is a French multinational corporation founded in 1665 in Paris. Originally a mirror manufacturer, it now also produces a variety of construction and high-performance materials.

The Foundation *La main à la pâte*, as the National centre of the Houses for science network, has established a partnership with Saint-Gobain which is a good example of a fruitful collaboration between schools and industries.

Each year, a training session is organised at the DomoLab, Saint-Gobain’s innovation centre for habitat, in Aubervilliers (near Paris). This site acts as a centre for experiencing sensations of thermal, visual and acoustic comfort and discomfort. The focus of the training is on insulation and energy in the habitat which are topics that can be reinvested afterwards in class projects with students.

As for the levers that encourage companies to engage with the Houses for Science, the most important ones are the contribution to the social responsibility of the company, and the better visibility of the company in the employment area. As those aspects form part of a long-term strategy for companies, the partnership is more likely to be sustainable.

On a practical point of view, the collaboration may be regulated by a convention that will detail various aspects: the choice of science and technology topics addressed, that should as much as possible match the business lines of the partner company, the type of involvement that depends on local context and identified needs, etc.

BOX 3

Partnership between the House for Science in the Alsace region and EDF (French national electricity company)

Testimony of Bernard Bloch, EDF Sustainable Development Officer

«The story of this partnership is first and foremost the story of a meeting between two worlds: education and industry. A story that begins in a particular context around the energy transition and the place of nuclear energy and originates from a convergence of views in the necessity to overcome prejudice and tackle hard facts. We decided to co-build a programme combining theoretical learning with on-site visits and meetings with experts from EDF and their partners from the worlds of energy and building among others. Our partnership began at the end of 2014 in line with the recommendations of the 2015 European Commission Report on Science Education for Responsible Citizenship:

- *Strengthening Collaboration with Business and Civil Society;*
- *Improve initial training, coaching and personal development of teachers;*
- *Link innovation strategy and science education strategy at local and international level.*
- *All in all, Science education is a key component to the continuous active citizenship education that starts in nursery school.*

Recently,EDF has reorganised its teams considering the French new regions. In our newly extended area called "Grand Est", we have already given our agreement to expand our partnership with the House for Science in Alsace, thus involving new teams and production sites. Projects abound. It's up to us to be creative and get out of the box to co-build new practices of training that are opened on both citizenship and business world"

"SCIENTIFIC PARTNERS FOR THE CLASS" PROGRAMME

"Scientific partners for the class" allow scientists to accompany projects, in some cases with companies, like Michelin (tyres' industry) or Aubert & Duval (alloys) in the Pilot Centre *La main à la pâte* of Châteauneuf-les-Bains (linked to the House for science in the Auvergne region).

Following this experience, the trainers from the pilot centre wrote a Guidebook «School and company, partners for a scientific project: taking action and learning together».

http://crdp-pupitre.ac-clermont.fr/ecole-des-sciences-63/

Below, their recommendations for successful science projects in the classroom with companies:

1. Choose the partner company according to your educational objectives;
2. Clarify upstream what the project will look like (scientific content, roles, schedule, etc.);
3. Reflect on shared issues between the Company and the House for Science;
4. Define a code of conduct and sign a partnership agreement with the company;
5. Establish the budget of the project;
6. Find partners outside the company and gather a steering committee;
7. Organise action in several stages;
8. Schedule a final wrap up day, involving all project stakeholders;
9. Provide feedback on the project;
10. Plan a new project taking the feedback into account.

LA MAIN À LA PÂTE PILOT MIDDLE SCHOOLS

In the *La main à la pâte* pilot schools, teachers define and implement unit or interdisciplinary scientific projects, in strong and constant partnership with laboratories and companies of their area. The collaboration between the different participants of the project is divided into different modalities: welcoming teachers in the laboratories or companies, visits in class of scientists and of corporate workers, scientific challenges proposed by professionals, loans of material, distant exchanges, collaborative projects between students, introduction to digital sciences, inverted classes, student placements in partner structures ... To be supported in this process, those pilot schools benefit from varied assistance:

- A **regional coordinator** is responsible for monitoring the schools and teachers involved in the project. They are also the entry point to the teams for the pilot schools.
- **Pedagogical and scientific tutors** ensure a concrete link between living science and the classroom.
- A **scientific mentor** follows the implementation of the project and comes to meet students and teachers in classes once or twice a year.
- **The Foundation *La main à la pâte*** provides the network with a dedicated professional development offer, an online platform and classroom resources in support of the schools' activities. Volunteer teams may even be involved in testing new resources or participating in their design.
- Finally, each pilot school benefits from an **annual subsidy** of 700 euros paid by the Foundation *La main à la pâte*. This grant is intended to cover unusual expenses related to the implementation of the project such as student trips, on-site visits (laboratory, plant), documentation, exceptional equipment, organisation of exhibitions targeted at families, etc.

2.2.5 Italy

The way schools and companies interact are various in Italy. First of all, many schools prefer to split the whole class in small groups and to make them collaborate with different companies at the same time. In such a way, the number of pupils each company has to work with is smaller and the results of the collaboration more efficient. This type of interaction is always really productive, because the number of students for each group is only 5 persons, thus the companies that receive the students can be small as well. When the project is developed in this "small-group-approach", the companies are usually near to the schools and less time and money is required. On the other hand, it is not always easy to find the proper interactions between many different companies and the same number of groups of students simultaneously. Thus, often it happens that some groups of students take part in work experiences while the rest of the class is attends their usual school lessons.

In order to avoid dividing the students into groups, many other schools prefer to select only the bigger companies where the whole class can work together at the same time. This approach removes the daily teaching issues however, new issues often arrive. In fact, it often happens that the companies big enough to host 25-30 students simultaneously, are far away from schools with associated transport and economic problems to solve. In both cases, one efficient method is to ask experts from companies to come and present the project and the company itself directly at school before the real students' working experience. In this way, time and money are saved. Also, at the end of the project, a final meeting at school is really useful in order to focus on the most significant aspect of the experience. This last point is even more important with the recent school reform that focuses part of the final exam on the working activity students completed in the companies. For this reason, the quality of the work done by each student is evaluated by a representative from the company and from the school and this evaluation is a part of the final mark.

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Recommendations

There are various options to make a successful school-company collaboration. The following ideas can be suggested at different levels of the education system.

To STEM teacher educators:

- It is important to know the pedagogical knowledge behind the school-company collaboration. Teacher educators should provide sufficient knowledge, materials and methods for professional development.
- Pre- and in-service teachers should have regular opportunities to practice school-company collaboration in authentic environments.

To school teachers:

- The teacher has an important role concerning successful school-company collaboration. The aim is that students are able to learn and connect subject kowledge to real-life examples.
- Pupils need to have opportunities to visit companies and have more information about companies, products, services and careers in order to acquire skills and knowledge for their future lives.
- If there is no possibility for every teacher to get involved in school-company collaboration, there should be at least 1 or 2 teachers who are qualified for it in each school.
- School-company collaboration needs time and effort. Therefore, it is important to cooperate with colleagues or professionals from the school, university or company. Resources can be saved if the companies are near schools.

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