Working with the schools

LINKS

Learning
from
Innovation and Networking
in STEM

Coordinator

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Introduction

"*Today's schools must equip students with the knowledge and skills they'll need to succeed in an uncertain, constantly changing tomorrow. But many schools look much the same today as they were a generation ago, and too many teachers are not developing the pedagogies and practices required to meet the diverse needs of 21st-century learners*" (OECD, 2016).

Schools need to react quickly to changing external environments, to embrace innovations in internal organisation, and ultimately to improve student outcomes. They should be supported in functioning as "learning organisations" "*[…] where the beliefs, values and norms of employees are brought to bear in support of sustained learning; where a "learning atmosphere", "learning culture" or "learning climate" is nurtured; and where "learning to learn" is essential for everyone involved*" (OECD, 2016): from principals to teachers, from students to parents.

An "integrated model of school as learning organization" was proposed (Fig 1), and it perfectly fits with the vision and contributions of the LINKS partners in working with the schools. It is based on the following seven action-oriented "dimensions":

I developing and sharing a vision centred on the learning of all students

II creating and supporting continuous learning opportunities for all staff

III promoting team learning and collaboration among all staff

IV establishing a culture of inquiry, innovation and exploration

V embedding systems for collecting and exchanging knowledge and learning

VI learning with and from the external environment and from larger learning systems

VII modelling and growing learning leadership.

All of these dimensions are essential for making school transformation sustainable. At the end, only if all the seven dimensions are realised, the whole will be greater than the sum of its parts.

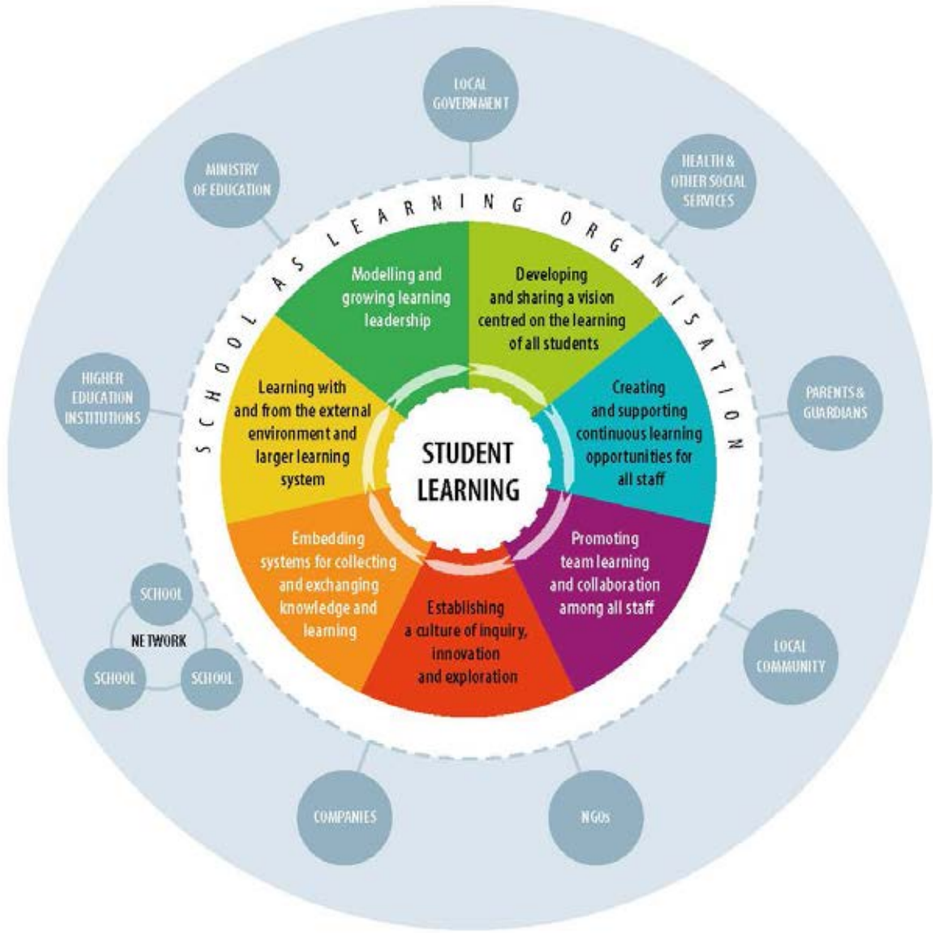

Fig. 1: The integrated model of the school as a learning organisation (OECD, 2016)

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Successful collaboration with schools

All LINKS partners are aware of the crucial role schools play in effective sustainable STEM CPD. In order to be effective, models for cooperation with schools have been developed and successfully implemented, adapted to national and regional contexts and taken into equal account the content and the structural and social aspects. The analysis of examples of collaboration from across the LINKS partners forms the basis of the common success criteria and recommendations reported here.

Examples from the LINKS partners

2.1 Finland

LUMA Centre Finland collaborates with schools in various ways, and the underlying idea is to help and to support teachers in their everyday work. These collaborations can include but are not limited to science fairs, larger projects implemented together, class visits to LUMA laboratories, etc. Depending on the form of collaboration, the role of LUMA might differ greatly.

One possible way for starting collaboration with schools is to invite teachers onto research and development projects. Teachers can, for example, test developed learning materials with their students and help developers to make the materials better. Often teachers appreciate this method because it eases their workload; in fact, for certain lessons, teachers get extra material for implementing their teaching. This method has been used especially with LUMA Finland Programme, where novel research-based methods were tested in pilot schools before a wider distribution.

Another way for starting collaboration is limited to LUMA Centres located in universities where trainee science teachers are educated; as practice has shown, this method is useful to such a degree that it should be mentioned. In practice, trainee teachers become familiar with LUMA activities and personnel as a part of their studies, and they get an overview about the possible support LUMA can offer. On one hand, this encourages them to utilise LUMA equipment, laboratories, and materials after graduation as they have seen the value of this already during their studies (see the box 1). On the other hand, it makes communication easier when people already know each other, which can be a surprisingly important factor for fruitful cooperation to get started in the schools.

Whenever possible, practical benefits for schools should already be introduced whilst making the first contact for possible collaboration schools. For example, practical help for their profession taking place in an actual classroom is an asset that teachers value as seen in the context of LUMA Programme; in that programme monetary support is possible (e.g. from sponsors) for schools in participating in activities, such as in the StarT model (see the box 2). Naturally, these sorts of benefits should never be the only reason for collaboration but sometimes they might be the key factor for schools that often suffer from the shortage of necessary resources.

These are just some individual examples about starting collaboration, and there are many more. For example, social media with its wide possibilities already has a firm foothold in all communications with schools, and these methods should be seen as equally valid nowadays. The more methods used, the more possibilities for collaboration

BOX 1

LUMA laboratories (located in certain Centres) and their equipment are one essential continuous collaboration activity between LUMA Centres and schools. There are several models for this collaboration: bringing classes to LUMA laboratories independently, bringing classes to LUMA laboratories for guided visits, and borrowing equipment for schools, with or without instructions. All these benefit schools as they can have access to equipment that typically schools cannot afford, and visits to new sorts of learning environments might motivate and intrigue learners towards science, especially when "wow effect" can sometimes be created with the aid of equipment. This form of collaboration is thought to be successful as practically all teachers participate in this model time after time, so they really seem to gain some benefit for their profession from this. Besides the afore-mentioned, we also educate teachers from all school levels in our laboratories (e.g. as a part of LUMA Finland Programme), which should encourage them to bring their classes to visit them in future.

BOX 2

The science fair model, namely **StarT**. This model is built to support schools in implementing phenomenon-based project learning that is strongly emphasised in the reformed National Core Curriculum. In StarT, students carry out projects related to science, technology or mathematics, and teachers get support (e.g. equipment, materials, guidance) for the school-level implementation from LUMA Centres. Besides this, all StarT projects can apply for local StarT festivals organised in all LUMA Centres and also to national and international series; the best projects will we awarded in all of these. Since 2016,the StarT model has expanded greatly, and currently there are hundreds of projects participating in StarT nationwide.

2.2 France

In France, each teacher is expected to build his or her own continuous development syllabus, notwithstanding the fact that the improvement in their teaching must benefit everybody in their school. Therefore the aim of the House for Sciences is not only to train teachers through CPD action, but also to promote working in teams and sharing teaching experiences in order to give added value to their involvement in a better teaching of their pupils.

Since September 2016, and throughout August 2021, the nine "**Houses for sciences**" network and the foundation La main à la pâte have been building a national network of 150 "**collèges pilotes**" (pilot middle schools).

The aim of this project is to promote a way of teaching science and technology that is genuinely formative and up-to-date by involving the participation and input of researchers, engineers and technicians.

Pilot schools are considered as prototypes where one can rely on the help from scientists and technicians to test new pedagogical methods.

Only interdisciplinary teams can be asked to join the network and may sign an agreement with the House for sciences.

[1] www.maisons-pour-la-science.org/colleges-pilotes

In each school, the programme relies on a team of 5 to 6 teachers, with a " liaison" teacher in charge of the day to day contact with the institutions, and an external scientific mentor.

Depending on their own history, schools join the network for various reasons:

- it may start with teachers thoroughly involved in numerous CPD actions at the "House for sciences" as trainees and desiring to form an interdisciplinary team of teachers in their school. The House for sciences then contacts them and their school head to join the network;
- through calls for projects aimed at middle schools organised by the local board of education (Rectorat);
- after a suggestion made by a teaching inspector who visited a middle school.

This project brings important upsides for the school:

- Each school is recognised as a place where innovation happens, and its role is advertised through several events, like inauguration, signage in the school, dedicated website at the regional and national levels, monthly newsletter highlighting the school's news.
- Participation of the parents and other citizens in milestone events organised in the frame of the project.
- Involvement of the local media in advertising various events linked to the project.

In 2017, the network consisted in 36 middle-schools, 69% of which being located in a « zone d'éducation prioritaire » (educational district with special needs and means, 12 middle schools) or in a rural area (13 middle schools).

The network has grown to 80 middle schools in 2019, with a steady growth expected until 2021.

In order to favour a bottom up approach, it is the responsibility of the teachers to initiate the project:

- each pedagogical team chooses a scientific theme that will define its school's project;
- and build their professional development track by themselves on the basis of their needs.

At the local scale, this implies the need for strong formal collaboration between:

- the teachers involved in the project;
- the head of the school;
- the professional development participants : the House for science, trainers from the ministry of education, researchers, private sector workers.

It also requires, at the regional scale, the collaboration between teams from different middle schools with the creation of a regional network of pilot schools. This is achieved through common professional development sessions organised and coordinated by the regional House for Sciences.

At the national level, a yearly workshop is also organised.

Thus, at various levels, the teachers benefit from:

- professional development training directly related with their school project.
- professional development training organised by the House for sciences at their school and involving scientists.
- talks by scientists in their classes organised by the House for sciences.
- an annual financial support for their project of at least 500€.

BOX 3

The House for Science in Brittany partners with 8 middle schools. It follows that 60 teachers and 62 classes, hence 1801 pupils, are directly involved in this collaboration (maisons-pour-la-science.org/bretagne/colleges-pilotes).

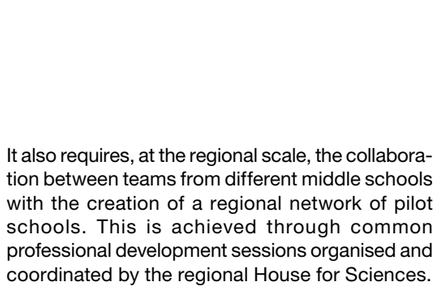

Fig.2 Map of the 8 pilot middle schools in Brittany

In one of these La main à la pâte pilot middle-schools an interdisciplinary project about beehives, bees and honey has been implemented.

For this project, teachers in the physical and chemical sciences, biology, mathematics, graphic arts, litterature and school librarians created an interdisciplinary team. They listed some needs, for example to identify various issues related with the environment and decided to teach them in the classroom.

One of the content was to explain the various food needs of human beings and the different means that have been developed to transform and keep this food (example of the honey).

This project allowed also to :

- describe the different states of matter at the macroscopic scale
- solve problems in various fields (geometry, physics, economy) dealing with numerical values, decimal or integer.
- compare, evaluate and measure geometric quantities with integer or decimal values such as length, surface, volume, angle.

The CPD actions offered support depending on the teachers' needs:

Different scientific supports were provided: beehive specialists, ethologists supported the teachers and their classes. Some technical supports were also provided: a beekeeper assisted the teaching team to install beehives near the « secondary school », and a technician assisted the teaching team to install and use an arduino module to measure different physical quantities related to the production of honey in the beehive.

A visit had been organised: a tour of beehives by the beekeeper for the teaching team and the pupils.

2.3 Austria

The Austrian programme **IMST -Innovations Make Schools Top-** is a flexible support system funded by the Federal Ministry of Education, Science and Research. The aim is to support teachers in implementing innovations in MINDT teaching (mathematics, computer science, natural sciences, German, technology) in Austrian schools. Scientists support teachers in improving their teaching. In the networks, teachers and teacher educators exchange ideas about teaching and schooling.

IMST pursues two approaches of promotion:

- thematic funding;
- funding in regional networks.

Every year, more than 4,500 teachers either carry out innovations themselves in their lessons or at their schools or organise themselves in networks in the federal states.

Since 2010, the so-called «theme programmes» have been promoting innovative teaching and school projects throughout Austria. Teachers were able to submit innovative teaching and school projects in various thematic programmes and further develop them in order to achieve a direct increase in quality in teaching and school on specific topics:

- e-Learning and e-Teaching (digital media, platforms and networks for teaching);
- competent through practical work (laboratory, workshop & Co.);
- competences in mathematics and science teaching;
- natural sciences taught in a gender-appropriate way;
- audit culture (performance and assessment in school);
- writing and reading (competence-oriented - interdisciplinary and differentiated);
- teaching computer science creatively.

Gender and diversity sensitive education plays an important role in all programmes (see box 4).

BOX 4

"Federal Seminar MINT - Potentials of a Gender Conscious Science Education"

School teams (at least 2 teachers from different STEM subjects) are accompanied by a tripartite training in order to initiate school developments towards gender diversity sensitive teaching. The programme is divided into 2 days of attributions of gender and diversity, 2 days of didactics and a wrap-up where the individual schools present their projects.

The teachers:

- develop their knowledge of gender and inequalities in schools and the world of work;
- are also particularly concerned with the dimensions of STEM and gender in the didactic aspects of the project;
- develop goals and measures for the further development of their STEM teaching.

The participation in this seminar series gives an impetus for the continuous school development, which is carried not only by individual teachers, but by a team.

In addition to financial support, IMST also offered teachers support in terms of content by programme teams (consisting of scientists at teacher training colleges and universities as well as school practitioners) over the course of a school year. A central aspect in these projects is the accompanying action research by the teachers, which combines the development of innovations with the gain of knowledge for teaching and learning.

The programme attaches importance to carrying out the projects as a team of teachers in order to provide an impulse for sustainable school development.

The project reports and a multitude of good practice examples are published in the internet platform «IMST-Wiki». With over 1000 contributions, the IMST Wiki offers an extensive selection of examples from teaching and school (see box 5). Teachers have the opportunity to draw on the knowledge and experience of colleagues, take up ideas and use materials.

BOX 5

"Exploring Science with Fridolin"

The NaturErlebnisPark Science Education Centre has developed a teaching programme for inquiry-based learning in primary schools that combines a classroom project based on puppet science and problem-oriented science teaching with a CPD programme for primary school teachers. The combination of cooperative instruction development, practical work in class, accompanying action research and CPD units as well as the necessary material and personal support sets effective impulses for the implementation of inquiry-based learning.

In order to provide a low-threshold access to this teaching methodology, The NaturErlebnis-Park Science Education Centre (NEP) offers different forms of support for classroom teaching:

- NEP staff coming into the classroom and guide the science adventures;
- Complete challenge boxes including „letters from Fridolin" telling the challenging story and materials for hands-on activities;
- Materials and tools for lessons planned and guided by the class teacher;
- ""Hot-line-service" to answer teacher questions;
- Help with the organisation of excursions.

The co-creative development of teaching settings promotes the teachers' own initiative and enables the methods to be adapted to the needs of the respective schools.

The teaching projects are accompanied by a CPD offer on several levels:

- Content and didactic workshops;
- Co-creative workshops to develop teaching materials;
- Peer group exchange;
- Workshops for reflected practice.

Regional networks supported by IMST exist in all nine Austrian provinces. In some federal states, district networks have also been established in the compulsory school sector. The organisation of a Regional Network is carried out according to the framework conditions and prerequisites in the respective federal state. IMST has suggested setting up a regional steering group for the coordination of the network, in which representatives of the natural sciences, mathematics (if possible from the respective state working groups) and the state school council will participate. In addition, representatives of the teacher training colleges, the universities and other relevant environments may be represented or involved by delegates. However, the size of the steering group should not exceed ten persons. It is coordinated by a person chosen from the group («network coordinator»), who is also the contact person for IMST's national network office.

Tasks of the network programmes are:

- Organisation of exchange of experience and further training (through seminars, workshops, conferences, newsletter contributions).
- Supporting the formation of focal points and their further development in schools.
- Development of a consulting pool for didactic and school development related consulting.
- Establishment of a contact point for schools and teachers.
- Participation in the establishment of a national steering group for the IMST «Regional Networks».
- Evaluation of the impact of the regional network.

BOX 6

The Regional Educational Competence Centres (Austria)

Regional and National Specialist Didactic Centres were established at universities and colleges of education as important support measures in the IMST support system.

Since 2014, centres that meet certain quality criteria have been certified with the quality label «Regional Educational Competence Centre (RECC)». Important prerequisites for the RECC quality label are specialist didactic research, initial and continuing training and networking with the regional specialist institutions of a federal state in the fields of science, school practice and education authorities.

The RECCs support CPD and teaching but also school development at several levels:

- High expertise in the field of didactic research;
- Teachers are provided with didactic findings and the results are published in specialist publications;
- Proven quality in the integrative and cross-school education of students and school practitioners;
- Committed promotion of young academics, e.g. by supervising didactic bachelor's and master's theses, dissertations and postdoctoral theses;
- Close networking with regional/national/international tertiary educational institutions and successful cooperation with the education authority, regional networks, and stakeholders from industry and the regional authorities;
- Targeted implementation of gender and diversity measures;
- Targeted support for schools in innovative school projects;
- A well thought-out evaluation concept;
- Practice-oriented didactic research and development with cooperation partners;
- Didactic education, training and further education of students/school practitioners;
- Cooperation between school practice, science and school authorities;
- Cooperation with schools, regional network and other educational institutions;
- Support of teaching development by accompanying and supervising school innovations;
- Quality development and quality assurance measures;
- Measures in the field of gender and diversity;
- Participation in the subject-related regional education planning.

2.4 Italy

ANISN is an association for in-service training of teachers and trainers; because of that, ANISN has a close collaboration with schools and involves teachers and other staff members in training processes in order to meet their needs.

Despite many differences linked to various contextual needs, there are key and constant elements on which ANISN's actions are based:

- the CPD in which teachers and schools are involved has a duration of at least a year;
- differentiated multilevel training offer (for beginners, experts and trainers);
- involvement of the headteacher of the involved schools;
- creation of permanent and multilevel schools networks (at local level in continuous relationship with the IBSE centres, at multiregional level for specific projects and at national level for IBSE systemic projects);
- creation and support of "communities of practice" within schools, between schools in the local network and between networks of schools in different regions;
- preparation of teaching materials to be used in activities with students (learning units, teaching plans, student worksheets, etc.);
- preparation of kits with materials and tools useful for experimental activities;
- contacts with scientists and researchers from the University and from the National Scientific Academy;
- documentation of the processes and the products;
- organisation of teachers' presentation of the work they did in their classes, with the involvement of students.

Collaboration with schools is never direct but always takes place through teachers, who represent the key contact for ANISN.

In the majority of cases, teachers' participation is on a voluntary basis: the training initiatives do not involve any selection for the teachers, nor any constraints or requirements for the schools to which they belong. At least in the initial phase, teachers' participation does not require any transition from the service school, nor the authorisation or consent of the head teacher.

This mode is the most widespread, for example it was used in the long-term training programme "Scientiam Inquirendo Discere – SID" and is still followed by regional and local IBSE ANISN pilot centres. Each pilot centre is affiliated with 5-15 schools, where 20-60 teachers are involved in SID-CPD each year. At national level, this programme is implemented in 20 Italian cities. In 2017-2018, more than 2,000 schools, 5,000 teachers and 20,000 students (aged 4-17 years) were involved.

Teachers who decide to join the programme, participate in the training, which provides a multi-level training offer, with paths at the basic level, for those who have no experience of the inquiry approach, and advanced level. Each centre provides teachers with the necessary resources and materials to experiment inquiry activities in the classroom and also provides support from the centre's trainers or managers. Teachers can therefore begin their training without the involvement of their own school, which usually occurs at the time of joining the network of schools affiliated to the IBSE centre of reference (see box 7).

In some regional IBSE centres, networks of vertical schools (from lower to higher level) have been created, in order to guarantee continuity in inquiry learning for children of a given territory. The schools of regional networks share the activities they carried out during the events concluding the school year, when students and teachers present their experiences.

The ongoing collaboration with schools is essentially due to the ANISN choice to promote long-term training programmes articulated in different activities, rather than training limited to a single event. This proposal, although more challenging, boosts the participation of schools. Moreover, often schools choose to include these training proposals in their own "three-year training plan", encouraging the participation of more teachers.

Some of the key elements mentioned above have proved to be particularly effective in developing and implementing long-term teachers training programmes. For example, involvement of the headteachers in the formal aspects and in monitoring and evaluating the training courses is strategic. The implementation of long-term projects has also led to two new aspects: the differentiation of the training offer into different levels courses (basic and advanced) and the selection of expert teachers for involving them as trainers of colleagues in the local or regional network. The presence of trainer teachers, in addition to encouraging and consolidating the dissemination of good practices within the school, also responds to the need shared by the LINKS partners to promote training made with teachers, rather than for teachers.

BOX 7

The local partnerships of an ANISN IBSE Centre

The IBSE ANISN Centre in Pisa is based, as the other nine in Italy, on a fruitful cooperation with local institutions (scientific, educational, civil society) and a stable networks of schools such as The ASTRA Network and Pisa network@schools.

The **ASTRA Network** includes the 15 Comprehensive Institutes (about 120 schools) of the Pisan area formed by 6 municipalities. It was founded in 2012 with the aim of achieving, through mutual support and joint action, the improvement of the quality of school service, the development of innovation, experimentation, educational research and staff qualification. In fact, the network promotes/enriches planning, communication, the exchange of ideas, the documentation of experiences, the production of shared materials and certainly contributes to reducing the self-referentiality of individual educational institutions involving them in the preparation of common ways of validating experiences. In recent years, while respecting the autonomy of each institution, various projects have been presented and implemented with a good impact on the quality of the school.

Fig. 3 The ASTRA network in Pisa

The ASTRA network has participated in the following teacher training projects:

SID –Scientiam Inquirendo Discere programme (since 2012); Project SCIEN supported by Ministry of Education (2013-2015); Scientific knowledge laboratories (since 2012).

The **Pisa network@schools** includes all comprehensive (primary + lower secondary schools) institutes (15) and secondary schools of Pisa and Cascina (6 schools).

The networks of schools make use of the partnership with: ANISN and ANISN section Pisa, Municipality of Pisa, Regional School Office, CNR (National Council of Research) Telematic Institute, University of Pisa, Sant'Anna High School of University Studies and Further Education, Scuola Normale Superiore di Pisa, TIMESIS Agency for Evaluation.

The ASTRA network and the Pisa network@schools, in cooperation with the above instititions and European partners (Universities of Brittany, University of Patras, University of Malta) led an ERASMUS plus project for PD training : Teaching Experimentation in Science and Technology (TEST) years 2015-2018.

TEST integrated different knowledge and skills, which are functional to the achievement of innovative teacher training programs and which are implemented through unconventional and creative methods, involving academics, professors from academic institutions, expert teachers from all types of schools and educational advisors.

The overall aim has been the development of science education research and enhancement of inquiry methodology implementation with particular attention to the planning and application of new technologies.

The main objectives were to:

- provide new teaching skills to teachers in order to achieve an improvement in Science education quality and to offer training courses and didactic proposals best suited to the new social needs and closer to pupils' interests.
- create educational research working groups (scientists, teachers, experts) to promote the development, testing, implementation and dissemination of innovative methods in Science education and to strengthen the cooperation among different prestigious European institutions.
- improve Science teaching, orientation and learning through a European collaboration among teachers, researchers and students also on the effective use of Information and Communication Technologies, thus establishing a profitable exchange of best practices in Science education and teacher training;promote technical-scientific culture in schools.
- encourage a better use of scientific laboratories and multimedia tools.
- raise a widespread awareness of the importance of Science and Technology for everyday life citizenship and for society development.
- trigger processes of integration, dissemination and transfer of proposals, models and results between TEST partners.
- Each year, about 110 teachers have been involved, 2.300 students (4-16 ys), 35 hours/ teacher of face to face training, 15 hours/ teachers of implementation at schools.

BOX 8

The most recent ABE (Amgen Biotech Experience) training programme proposes a different way at the time of accession, while maintaining the direct relationship with teachers, who, also in this case, are still the privileged interface of ANISN.

ABE is an innovative programme for secondary schools science teachers, based

on experimental paths of molecular biology. ABE is coordinated by the EDC (Education Development Centre) and funded by the AMGEN Foundation. It is currently implemented by a network of ABE sites distributed worldwide .

Since 2017, ANISN has been coordinating the Italian ABE site, a member of the international network, which has currently activated the ABE programme within a network of schools on a multi-regional scale.

The programme is launched every year by a public call, through the institutional channels of MIUR and the ANISN website, addressed to teachers and schools, who can apply and be selected on the basis of specific qualifications and requirements. For example, schools must have laboratories suitable for carrying out experimental activities, and must guarantee a programme of activities with students lasting at least 20 hours. Selected teachers may participate only if they have received the consent and authorisation of their Headmaster, who undertakes to ensure their participation in the intensive and residential training course.

The programme offers to participating schools an intensive and residential training of selected teachers focused on the basic techniques of biotechnology. It is carried out in laboratories with advanced equipment and under the guidance of researchers from the University Federico II of Naples. The training also includes the deepening of innovative teaching methodologies and the analysis of useful teaching resources.

It also provides participating schools with the equipment and consumables necessary to carry out the laboratory activities with the students. During the planning and the implementation phases, teachers can count on the support of the researchers who led the training path.

It allows teachers from a same school to work together on a same topic.

The exchange of information between various schools is possible thanks to a document repository, in which teachers share and compare their experiences with students, and also thanks to the organisation of public events for presenting the results reached by each school. The programme has a territorial organisation, divided into a system of regional or multiregional centres, with networks of affiliated schools, whose membership is formalised in the initial phase. The dissemination and expansion of the network of schools is guaranteed by the activation of advanced level courses, which supplement the basic training courses repeated each year.

Started in 2017, the ABE project has already enabled the creation of stable networks of ABE veteran schools, to which new schools are added year by year, according to a scheduled scaling up plan.

In the school year 2018-2019 ABE Italy involved 60 teachers from 36 schools located in 8 different regions engaging 1.500 pupils (16 -18 years) (http://abe.anisn.it/it/).

2.5 UK

With 100% of UK secondary schools and colleges and 80% of all primary schools benefiting, STEM Learning offers a wide package of support for schools, funded by a unique partnership of Government, Charitable Trusts and Employers. These multiple funding streams help to ensure long term financial sustainability. Around 27,000 days' worth of CPD are delivered yearly throughout the Network.

Over 3,000 educators benefit from residential CPD at the National Centre in York each year, with another 20,000 receiving high quality STEM-specific CPD locally through Science Learning Partners. The network of 40 Science Learning Partnerships (SLPs) are led by local teaching school alliances, schools and colleges with excellence in science, higher education institutions, and other local partners with cutting-edge expertise in science. They are able to offer bespoke CPD in shorter sessions within the local area, perhaps for one day or as twilight sessions after school, tailoring the CPD to specific local needs. This network of regional partners achieves a scale of delivery which would not be possible through the National Centre alone, increasing reach and impact.

The whole Network CPD has (conservatively) positively impacted over 4,000,000 pupils, with STEM Ambassadors reaching 900,000 young people per annum.

Among other projects, ENTHUSE is a funding partnership that was launched in 2008[2].

All organisations involved came together to bring about inspired science teaching through the continuing professional development of teachers of science across the UK. Project ENTHUSE funding allows the provision of subject specific CPD for teachers, technicians and other support staff at the National STEM Learning Centre in York and through partners in Northern Ireland (Department of Education Northern Ireland), Scotland (SSERC) and Wales (Techniquest).

ENTHUSE Partnership funding enables groups of four to eight schools and colleges to work together, with support from STEM Learning and an industry sponsor, on a two-year intensive programme to raise students' aspirations and achievement in STEM subjects. There have now been nine cohorts of ENTHUSE Partnerships since 2014, supporting over 500 schools (66% primary and 34% secondary or FE).

Partnerships can be selected to target a specific location or support other sponsor objectives, such as widening participation. STEM Learning consults with the sponsor and identifies schools and colleges who will benefit most, drawing on our extensive experience with Partnerships plus insight on potential participants from our nationwide network, as well as data on pupil attainment, school performance and socio-economic factors.

ENTHUSE Partnerships develop strong and sustainable relationships between the sponsor and the participating schools and colleges. These relationships increase visibility with teachers and students, strengthening the skills pipeline for STEM as well as contributing positively to improving the outcomes for local young people and communities.

The start of each Partnership is celebrated at an induction event, held at the National STEM Centre in York. This brings together teachers and school leaders with key staff and STEM Ambassadors from their sponsor. Workshops and networking opportunities at the event further embed relationships and commitment.

Throughout the life of the Partnership, STEM Learning supports the sponsor and participants to build links with the local community which can include holiday STEM Clubs, STEM activities for youth and community groups and STEM courses for parents and guardians.

The Partnerships choose their own focus, based on local needs, and can access up to £20,000 worth of support from a wide ranging offer, such as face-to-face residential CPD, local bespoke CPD, in-school consultancy, teacher placements in industry and a contribution towards the cost of releasing teachers from the classroom (Fig.4).

Fig. 4 Menu of support available for ENTHUSE Partnerships

Each partnership has a lead school, and every school has its own lead teacher who attends regular partnership meetings on behalf of their colleagues and contributes to the development of a joint action plan. Many of the lead teachers have been new to the role of Science Coordinator in their school, and they have indicated that leading network meetings, working with teachers to assess needs, deciding how to use the funding efficiently and planning how to cascade the learning all contributed to the development of their own leadership skills, further building capacity within the schools and providing sustainability.

[2] With £27 million from the Wellcome Trust, the Department for Education, AstraZeneca, AstraZeneca Science Teaching Trust (renamed Primary Science Teaching Trust in 2013), BAE Systems, BP, General Electric Foundation, GlaxoSmithKline, Rolls-Royce, Vodafone and Vodafone Group Foundation. In 2013/14 Project ENTHUSE received further funding of over £22 million from the Department for Education, the Wellcome Trust, BAE Systems, Biochemical Society, BP, Institution of Engineering and Technology, Institution of Mechanical Engineers, Rolls-Royce, Royal Commission for the 1851 Exhibition, IBM, Institution of Structural Engineers and the Royal Society of Chemistry.

BOX 9

Evaluation of ENTHUSE

An external evaluation of the ENTHUSE Partnership Programme (EPP) found that 91.8% of school partnership lead teachers, 89.3% of school leaders and 65.8% of teachers reported increased involvement in collaborative work with other schools within the partnership as a result of the EPP. The feedback from schools was that it was beneficial to go into other schools to see what they had done and especially to observe lessons. Teachers could then implement ideas having seen them in action. Many schools reported creating links and sharing benefits to schools beyond their Partnership by 'reaching out' with projects, events and further training opportunities (External Evaluation of the ENTHUSE Partnership Programme, 2017, CUREE).

The evaluators also found that Partnerships are using funding efficiently to combine internal and external expertise, for example by sending individuals for intensive professional development with subject specialists at the National STEM Learning Centre, and then cascading the learning from courses to the leads in other schools and in whole-staff training sessions within their own schools to share the benefits as widely as possible.

Independent evaluation also shows that the support provided by ENTHUSE Partnerships improves teaching and teacher retention, tackling the shortage of teachers with STEM knowledge. It increases young people's interest and attainment in STEM subjects, as well as awareness of STEM careers, and the evidence suggests pupils receiving free school meals benefit even more than their peers.

STEM Learning has also created **Science Mark**, a quality standard designed to recognise and celebrate inspiring practice in secondary and FE science departments across the UK.

There are three levels of the award - silver, gold and platinum – which look at a range of factors which contribute to excellent teaching and learning in science. Teachers in a science department assess their current position in relation to a set of criteria for each level, and then work towards achieving Science Mark at the appropriate level. STEM Learning provides half a day of support from an external expert who helps the school to develop an action plan to address needs and work towards the award. Heads of department have reported using the award as developmental and as a basis of their yearly improvement plan.

The benefits of achieving Science Mark include:

- raising the profile of science across the school or college;
- demonstrating the school's commitment to quality standards in science education;
- celebrating engaging, stimulating and inspiring lessons for students;
- receiving a plaque, certificate and digital banner.

«Science Mark is something we're really proud of. It's given us a great sense of achievement and pride.» - Head of Science

	Silver	Gold	Platinum
1	Students are making and exceeding progress at least in line with national expectations, as outlined in the RAISEonline transition matrices. ☐	Most students are making and exceeding progress above national expectations, as outlined in the RAISEonline transition matrices. ☐	All groups of students are making and exceeding progress that is well above national expectations, as outlined in the RAISEonline transition matrices. ☐
2	Teachers have good subject expertise and develop students' understanding of the 'big ideas' and interconnectedness of scientific concepts. ☐	Teachers make effective and creative use of subject and pedagogical knowledge so students benefit from an imaginative and skilfully planned curriculum. ☐	Teachers continually challenge and exploit their own, and their students', subject knowledge giving a curriculum with imaginative and relevant contexts. ☐
3	All students' needs are met by the good delivery of appropriate courses and differentiated provision. ☐	Students are fully involved in a wide range of practical work. It creates a range of opportunities for strong spiritual, moral, social and cultural development. ☐	All students' needs are met by innovative planning, delivery and continued evaluation of this curriculum, which actively enthuses and prepares them for making the transition to further study and training. ☐
4	Students benefit from an enriched and enhanced curriculum, and opportunities to work with other departments or partners. They have an awareness of local scientific issues and are curious about the world they see around them. ☐	Students are regularly offered opportunities to work with other departments or partners within and beyond normal curriculum time, and experience how scientific concepts and processes are being used by scientists to make discoveries and inventions. ☐	Students can proactively and independently use concepts and processes to understand phenomena and features of their locality, as well as critically evaluating projects that science can help to address and opportunities that science can help realise. ☐

Fig. 5 Science Mark

3

Lessons learnt: common themes

A comparison of the school-related measures in the LINKS partner institutions reveals a number of key aspects which are common to all models, and are viewed as essential for the successful implementation of a culture of innovation and reflective development in schools..

3.1 Partnerships

In all networks involved in LINKS, it is evident that an essential factor for a sustainable STEM-CPD culture in schools is the establishment and maintenance of partnerships at different levels.

The word «partnership» implies cooperation and an appreciation of differences in expertise and competences. Successful partnerships offer all stakeholders a balance between the contribution of resources and the benefits derived from them. **Sustainable CPD cannot be done TO teachers, it must be developed and organised WITH teachers**.

In the analysis of LINKS networks, it is clear that this requires a combination of different factors, including organisational, thematic and social components.

3.1.1 Fostering cooperation and networking of teachers

A strong motivational factor for taking sustainable steps towards one's own professional development is networking with other teachers. Partnerships can arise between individual teachers at the same school, between different schools (e.g. in school clusters) or also in theme-related regional and national interest groups.

A cooperation-friendly design of CPD programmes can contribute a lot to teachers forming peer groups, supporting each other as «critical friends» or initiating permanent cooperation between individual schools.

In the LINKS network, there are several good examples of building learning communities in CPD programmes where an exchange of experiences takes place over a longer period of time. It has also proved successful to target teams of teachers, rather than individuals -either from the same school or from different schools- and to promote joint development and evaluation of teaching methods.

School directors play a decisive role here, providing time and space for cooperative work and ensuring an innovation-friendly climate in their respective schools. Effective CPD programmes therefore involve school leaders in the planning, organisation and evaluation of training activities and maintain communication with headteachers.

3.1.2 How to increase reach

CPD providers are often confronted with the fact that the same group of people participate in projects and workshops. A decisive factor for the sustainability and broad impact of cooperation with schools is therefore to develop effective approaches to address schools not yet involved in the programmes.

There is no single way for starting collaboration with schools; in order to reach as many schools and teachers as possible, one should utilise various methods. It is often a hurdle for newcomers to get involved in complex and challenging projects. Therefore, it makes sense to also offer low-threshold possibilities to get started with CPD programmes. Approaches that have proven particularly effective include testing materials and methods that can be directly used in the classroom, short-term workshops or regionally organised events with an emphasis on the social component. A rich network of personal contacts can be helpful in all forms of starting collaboration. Even more important, schools and teachers should always see the benefit that the collaboration can bring for them; typically, teachers do not buy an idea based on marketing but need to see evidence.

3.1.3 Strengthen existing partnerships

Partnerships can rarely be prescribed top-down. It is more promising to build on and promote existing links between individuals or schools. The freedom to choose partners plays an important role in how resiliently and sustainably such a partnership can develop. CPD programmes that allow schools to choose their own consortium are sometimes superior to rigid forms of organisation in many respects.

3.1.4 Establishing partnerships on all levels of CPD organisation

Not only between individual teachers or schools, but also within the CPD organisation, the establishment of stable and continuous partnerships has proved its worth. These involve the long-term commitment of strategic and political stakeholders as well as pedagogical and scientific experts in steering committees in order to facilitate intensive commitment and stringent further development.

3.2 Broad CPD model

The LINKS institutions argue for the establishment of a broad model of the CPD organisation that allows different forms of durable cooperation between teachers, schools and CPD providers.

The choice of organisational format has an impact on the establishment and maintenance of partnerships.

In addition to a broad offer of periodic face to face training courses, there are times in a teachers' career when immersive CPD is needed.

Online/distance learning CPD may engage those teachers who, for geographical or financial reasons, cannot join face to face courses and workshops. However, in order to establish long-term cooperation and innovation, partnerships supported by personal contact, at least occasional face-to-face activities, are required in addition.

Residential courses give teachers a 'thinking space', away from the everyday school life, in order to reflect on what they have learned and to consider how they might adapt their teaching. The time to share experiences with colleagues from different schools is also invaluable.

At other times, shorter training on a very specific aspect of teaching is needed (e.g. a half day looking at some new approaches for teaching energy).

A regional network of CPD providers can respond to such local needs and deliver CPD at the school.

Projects are usually more complex and time-consuming, but they allow teachers to respond to the specific local situation and to react flexibly to changing conditions. The discourses necessary for project implementation create a shared basis in terms of content and philosophy and thus represent a good starting point for further and more demanding cooperation projects.

Regional focal projects in the CPD make it possible to work with a whole school («internal school training») or several schools in a region. The resulting relationships have a high chance of continuing even after the CPD activity has ended.

National CPD programmes allow a basic pedagogical-didactical consideration of current challenges in teaching and in incorporating leading findings from educational research and the natural sciences. Such experiences can be very motivating for individual teachers to participate in CPD programmes in the longer term and to act as multipliers in their environment. For CPD providers, long-term partnerships with teachers provide the opportunity to tailor their offerings closely to common needs.

European Networks and Projects provide many opportunities to establish personal connections between schools from different European countries, which offer a good basis for a multi-perspective reflection on socio-scientific topics.

3.3 How to foster the schools' long-term involvement

Getting schools to participate in cooperation for a long time period is a constant challenge, especially in countries where CPD does not get the monetary support from the government level but it is a local responsibility. Thus, this challenge cannot be solved only by CPD providers but it also touches teachers, municipalities, school principals, decision-makers, etc.

However, the most essential factor for getting schools and teachers for participating in long-term collaboration is that they get benefit from CPD; naturally, schools and teachers themselves do not put effort for participating in activities they do not value. When this baseline is guaranteed and shown, teachers and schools themselves might take an active role for enabling long-term CPD for themselves, which is a pre-condition for them.

Teachers themselves are often keen on participating in long-term CPD –including in team- when they are supported by their schools, the main challenge being to free them from their teaching duties for that purpose.

BOX 10

One example has taken place under one sub-project, namely **Matikkakukko**, of LUMA Finland Programme where teachers were freed from their teaching duties for six days, and salaries for their substitute teachers were paid by the municipality. The underlying idea in this was what the teacher participating in these CPD sessions can educate his/her colleagues furthermore to some extent, and thus this municipal support helps numerous teachers. These types of agreements are always made individually for each project, and they get a lot easier when all three quarters (LUMA, schools, local decision-makers) are involved in these negotiations.

For this afore-mentioned scenario to take place, a CPD provider has to be active and be in a close contact with teams of teachers, as only by these means teachers' long-term involvement can be supported.

To build a productive relationship between the teams and the committed institutions requires time, and one needs to make sure that this time will remain available throughout the duration of the projects. Therefore this time must be made available by the school head in the classes' and teachers' schedules.

Many means may be used to encourage the collaboration with outside institutions:

- face to face learning: meeting and CPD ;
- distant learning through virtual classes and MOOCs
- access to a sharing platform aimed at exchanging resources and keeping in touch between face to face meetings.

The network is the place where people may reflect about their own experience and provide a feedback to the other people involved. It is of paramount importance in order to improve one's practices. The project duration, 5 years, is thought to be enough to provide the hindsight and feedback that are necessary to do so.

Beyond the core team in each middle school, the project is also a means to motivate and encourage the other teachers to create and experience new methods through their contact with the scientists and CPD trainers.

The proposal of programmes with different levels of training (basic and advanced courses) encourages the long-term participation of teachers, with the prospect of a progressive consolidation of the acquired practices. Multi-level training courses involve a complex management, for example, in terms of the resources needed, but it can be taken on also organising training at local or regional level.

Diversified training programmes implementation has highlighted that the continuity in the relationship with schools can be achieved through different ways.

For example in Italy, the ANISN-IBSE training centres offer a wide range of training initiatives, aimed at teachers of all school order, without any constraints or specific requirements at the joining time. In this way, the schools have the opportunity to satisfy diversified training needs. The ABE project, on the other hand, is a much more structured training proposal, conditioned by specific constraints and requirements imposed on teachers and schools. The result is the early formation of networks, which are homogeneous in composition and aligned by needs and affinities (see above boxes 7 and 8).

3.4 Ownership

"In a school as a learning organisation, staff are fully engaged in identifying the aims and priorities for their own professional learning in line with school goals and student learning needs, as defined in the school's development plan" (OECD 2016).

In a systematic review of the best evidence from over 20,000 research studies, The Centre for the Use of Research and Evidence in Education (CUREE) found that the most effective CPD allows teachers to develop ownership of their learning, by offering them scope to identify or refine their own learning focus and to take on a degree of leadership in their CPD. Positive outcomes for teachers and students were also seen in programmes where teachers were able to work collaboratively with colleagues, creating ownership through collective responsibility for each other's learning (CUREE, 'Continuing professional development (CPD): the evidence base' *https://www.nationalcollege.org.uk/cm-mc-lpd-resource-cpd-evidence.pdf*).

Cultural change and a shift in practices within a school are more likely when teachers and school leaders work together to identify their own professional development needs, and teachers are actively involved in bringing about that desired change (Kudenko et al, 2018). Hence, professional development should not be something that is done to teachers, but with them.

When teachers are supported in working together in professional learning communities, both within and across schools, in order to develop their own shared vision for self-improvement, this collegiality can promote a culture of inquiry and innovation. Evidence shows that this has a positive effect on teachers' motivation to stay in the profession and on career progression for the teachers leading the collaborative work.

However, a school's capacity for self-improvement may be limited by the increased workload for teachers unless time is protected for reflection and collaboration. Additionally, as schools often lack the capacity and level of expertise needed to deliver subject-specific CPD internally, the impact of school-led improvement on student outcomes may be limited without input from external science education experts, who can provide well-researched examples of effective practice and subject knowledge enhancement (Kudenko et al, 2018).

Therefore, in order for teachers to retain ownership of their learning, have the support and guidance of their colleagues and school leaders, and have the opportunity to engage with a range of impactful professional development, a blended model combining the benefits of school and teacher led self-improvement with externally provided, subject-specific professional development is recommended.

(Kudenko, I. Hoyle, P. and Dunn, B (2018) 'The value of school partnerships in improving primary science teaching: a comparison of two PD engagement models').

3.5 Engaging research (scientific, educational)

Schools as institutions and as communities of teachers and learners play a crucial role in fostering a culture of research-based innovation in STEM teaching. On the one hand, the respective scientific disciplines and, on the other hand, the educational sciences are to be regarded as reference theories for science teaching. Effective CPD enables teachers to keep up with research, developments and findings in both fields of science. This is important because only this kind of twofold support for teachers enhances their knowledge and understanding and helps them to support students' learning in a best possible way.

As far as the cooperation of schools with natural scientists is concerned, we also refer to the guidance tool «Working with the Scientists», in which this aspect is explained in detail.

In the following sections, the role of schools with regard to the integration of current educational science findings in STEM subjects and teachers' professional development will be discussed.

Schools are where current educational science findings are put into practice, but also where the educational sciences gain the foundations for the further development of educational theories. As in other social science and educational contexts, approaches that combine empirically gained educational science findings with the development of concrete practice-relevant improvements are increasingly gaining importance in teaching and professionalisation in STEM teaching. Therefore, the LINKS partners regard schools not only as recipients, but also as contexts of educational research and as producers of educational science findings.

Contemporary CPD takes into account this increasingly active and research-related role of schools and supports teachers and schools in building appropriate competencies of reflected practice and impact research. Intermediary institutions, such as many of the LINKS partners, represent the link between schools and research. They disseminate and explain educational and scientific findings to schools and help to develop concrete teaching methods and materials based on them. This means that CPD both fulfils the function of making current educational science findings accessible to teachers and supports them in putting these findings into practice. Additionally, we found that CPD providers are crucial for promoting methodological approaches to evidence-based teaching development, practice research and action research, and adequate formats of impact evaluation.

The claim to theory-based development and reflected practice, however, is not only directed at schools and teachers, but also concerns the CPD providers themselves. The LINKS partners therefore call for the following aspects to be considered in the professional development of teachers, but also in the structure of CPD providers.

3.5.1 Continuous evidence based development through adequate CPD structure

Structural conditions of the CPD can make a significant contribution to ensuring that schools continuously orient themselves towards current educational science findings and further develop their own practice on the basis of evidence and theory. CPD programmes, which are iterative and medium to long-term, form a good basis for establishing research-related school development. Cross-institutional CPD programmes, in which university educational research is also integrated, promote the establishment of a reflective and evidence-based culture of teaching development.

3.5.2 Promotion of Action Research in the schools

CPD providers encourage schools to combine pedagogical learning and practical development of teaching approaches in repeated cycles of action research (AR). By establishing links between their local knowledge and the findings in educational science, schools can question their implicit theories of teaching and learning and gain theoretical perspectives on the specific context.

AR-specific methodological approaches, such as the concept of «critical friends» or the triangulation

between external feedback and self-evaluations with different methods, are helpful in order to comprehensively consider challenges in the classroom and to be able to take targeted measures.

Long-term, team-oriented CPD programmes help to build up appropriate methodological competence at individual schools and establish a spirit of reflected practice among the teachers.

3.6 Recognition and reward

Innovation and continuous professional development require from schools and teachers a high level of commitment and a considerable amount of time and effort. The LINKS partners consider it desirable to honor this commitment with esteem as well as material recognition and thus provide an incentive for further schools to participate in CPD programs.

BOX 11

Recognizing and rewarding schools/ teachers in Finland mostly takes place in public events, and currently there are two essential ways for rewarding them.

One way to recognize schools is to organize science fairs, such as StarT festivals, and to reward schools/teachers with different justifications. The best projects are rewarded at local and national level based on pre-determined criteria, and these rewards can vary greatly; small products, gift cards, and money have been used. Besides this, typically the most active schools/teachers participating in StarT are awarded with gift cards, etc.

Another form of reward takes place during annual LUMA days where the most distinguished LUMA players are rewarded with monetary awards. Even if these awards are not solely directed for STEM teachers, typically these awards go for the most active teachers working in STEM education.

BOX 12

In the United Kingdom, the Network's recognition schemes and awards allow individuals, departments, schools and colleges to showcase their impact on young people, motivating them to continue their professional learning journeys and remain in the teaching profession.

Enthuse celebration awards

There are six categories in these annual awards:

ENTHUSE AWARD FOR EXCELLENCE IN STEM TEACHING – PRIMARY

This award is for primary teachers who have shown sustained impact around STEM teaching and learning.

ENTHUSE AWARD FOR EXCELLENCE IN STEM TEACHING– SECONDARY

Recognises teachers who have developed aspects of STEM education within their secondary schools.

ENTHUSE AWARD FOR EXCELLENCE IN STEM TEACHING – POST 16

This award is for teachers and further education lecturers who have developed STEM subject teaching in their organisation

ENTHUSE AWARD FOR EXCELLENCE IN STEM TEACHING– TECHNICIANS AND SUPPORT STAFF

Technicians and support staff are vital to effective STEM education and this award recognises and values those who contribute at the highest level.

ENTHUSE AWARD FOR SCHOOL AND COLLEGE LEADERSHIP IN STEM

This award is for middle and senior leaders who have effectively championed aspects of STEM in their school or college.

ENTHUSE PARTNERSHIP OF THE YEAR

ENTHUSE Partnerships are a unique local collaboration of schools developing their STEM subject teaching and learning, and this award recognises the high impact of these alliances.

Nicola Connor is Class Teacher at the Peel Primary School, Livingston, West Lothian and the winner of the 2018 ENTHUSE Award for Excellence in STEM teaching – Primary. Here, she describes the impact of winning the award:

"Winning the ENTHUSE Celebration Award in the category of primary schools has made a great difference to our school. The profile of the STEM work the school, teachers and pupils carry out has risen since winning the award. The school's community is aware of what pupils have been learning and taking part in, and are very supportive. We have taken part in further learning opportunities with new partners due to our increased profile and it has been great to see the motivation and enthusiasm from pupils across the school.

For me, as a teacher, the benefit was meeting like-minded teachers and professionals who are as passionate about promoting STEM as I am. It was nice to make new contacts and share ideas and projects. It was interesting to see the difference in the Scottish Curriculum to across the UK and links being made.

Winning the UK award was a shock! It has opened doors and opportunities for me personally. I am Primary Science Development Officer for West Lothian and working on the Primary Science Teaching Trust Sustain and Extend Programme. I am working with the Developing the Young Workforce team in West Lothian to develop STEM opportunities such as STEAM kits and have an input in learning. This wouldn't have happened if I hadn't won the award and I will be forever grateful for this."

Fig. 6 and 7 ENTHUSE Celebration Award

4

Recommendations to foster schools involvement in CPD

To CPD providers

1. Foster a broad range of partnerships involving schools

2. Teachers should be involved in deciding their own professional development needs, which should also align with the school/departmental development plan.

3. Promote the participation of teachers as schools' team and fostering the creation of learning communities inside the school connected with others at local, national and international levels.

4. Teachers' learning through CPD should be recognised by principals and senior leaders through the provision of dedicated time to share and discuss new ideas and practices with colleagues when back in school.

5. Involve school leaders and school staff members in planning, organising and evaluating training activities

6. The impact of CPD should be assessed after teachers have had sufficient time to embed new practice, and teachers should be supported in how to measure this impact so that they can become strategic users of CPD rather than ad hoc users.

7. Foster the development of intermediate leadership models (also offering specific training courses) to enhance and capitalize on the training experiences of teachers through the planning of spaces and devoted time of sharing and dissemination within schools.

8. A blended CPD offer can better meet the varied needs of schools and teachers in a long term perspective.

9. External input from science education experts is essential to provide well-researched examples of effective practice for schools, introducing fresh ideas as well as enhancing teachers' subject knowledge.

To Ministries and Educational authorities

1. Ministries should provide funds for supporting professional development at school level

2. School authorities should count specific CPD project work as working time (e.g. members of steering groups).

3. Adequate infrastructure for intermediate institutions enables the provision of teaching materials on loan as well as the individual support of schools.

4. CPD should be free for all teachers. CPD should also be organized so that schools/municipalities cover the costs, not the teachers.

5. A system of recognition would be desirable in which schools receive rewards in the form of human or infrastructural resources for CPD activities completed.

6. A blended model combining the benefits of school and teacher led self-improvement with externally provided, subject-specific professional development is recommended.

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