

**Building
comprehensive
partnerships and
alliances for
sustained CPD**



LINKS

Learning
from
Innovation and Networking
in STEM

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This publication is funded by the Erasmus + Programme of the European Union.



The European Commission support for this publication does not constitute endorsement of the content which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



Introduction

The LINKS partnership sets out to support and improve quality, inclusion and innovation in STEM. Partners involved in LINKS, organised in national educational networks, consider continuous professional development (in short CPD) of educators as the most effective mediating tool to enhance the achievements of pupils in STEM. However, to make the most of CPD benefits, it is crucial to design and implement policies and programmes that target effectively the needs of teachers. The LINKS Case Study collected innovative good practices rising to that challenge.

Yet another key task is gaining the support of decision-makers who are interested in expansive yet sustainable CPD strategies that traverse top-down policy lines. To raise a strong and long-lasting interest for the innovations featured by partner-networks, it is paramount to reflect on obstacles and opportunities our CPD activities face while enhancing teaching practices and learning outcomes.

Why networks for alliance building and sustained STEM CPD?

Education systems are becoming increasingly complex in the context of globalization and digitization on one side, and decentralisation and school autonomy on the other. Tools are in need that connect stakeholders within and between different levels of the educational system to achieve defined educational goals, greater inclusion and broader educational impacts. Networks are a tool for educationalists, such as policy makers, schools, school education leaders, teachers and a wide range of stakeholders to promote and support school development. Due to close connection, they are more apt to solve problems concerning the education of the younger generations in collaborative, flexible and innovative ways. In addition, networks can serve as an environment to explore and pilot new policies, pedagogical ideas and working methods.

Understanding how our professional networks function in their various ways was a starting point for the work on the crosscutting issue of “Building alliances and partnerships for sustained CPD in STEM.” Identifying the important elements to consider can help realising network goals, identifying opportunities for networking across school education systems, as well as contributing to a broad and embedded culture of learning. Not only do students and teachers have to learn and change, so do educational research and policy as a whole. We emphasize the system’s need for learning and this in return makes it easier for teachers (and students) to regard themselves as learners.

If CPD programmes are to be impactful and based on cutting-edge educational research, teacher educators need to be involved in the development and implementation of CPD programmes. In addition, teachers need to see their engagement as relevant and worthwhile. In short, the whole system needs to be involved in the research, development, and implementation of national CPD programmes to positively influence teaching and learning in STEM. (Krainer et al. 2013). One main mediation tool that enhances these processes are networks in STEM CPD.

Our priority with this brochure on the crosscutting issue “Building comprehensive alliances and partnerships for sustained CPD” is to establish when and how best to harness the potential of networks within different educational contexts. Additionally, we want to stress the potential benefits and challenges of doing so, drawing upon examples of our own network experiences accompanying our STEM CPD engagement. This booklet presents pivotal concerns as it considers how different types of networks have developed their practice and what might come next. Furthermore, we present difficulties met on the road and possible paths to overcome those.

How we drafted this booklet

Within the LINKS partnership, the IMST network coordinated the crosscutting issue “Building comprehensive partnerships and alliances for sustained STEM CPD.” Drawing on the results of the LINKS case study on innovative CPD practises, the partnership thus continued elucidating noteworthy aspects of our STEM CPD activities within a shared European frame. Looking at our work from a network perspective, we posed the following questions with the intention to further knowledge, analysis and shared visions:

- How do partners organize their networks? What are network strategies?
- How do LINKS partners broaden their network structures? What are favoured elements?
- Which difficulties do we encounter and how do we address them?
- How could we further enhance our networks?

In five chapters, this booklet sets out guiding principles for developments of STEM CPD networks. In offering takes on five European network examples, namely the French LAMAP, the Italian ANISN network, the Finnish LUMA network, the Austrian IMST network, the Austrian Science Centre Graz, and the British STEM Learning. The content derives from a series of online and offline meetings held in Vienna in autumn of 2018 and through self-reporting of the LINKS members

of our working group and the following peer-learning process. Colleagues associated with this process are Anette Markula and Oona Kiviluoto (LUMA Network) Adam Little (STEM Learning), Clément Varenne (Université Fédérale Toulouse Midi-Pyrénées), Pierre Bonnefond (Maison pour la science en Midi-Pyrénées), Gabriela Baron (ANISN network) and Doris Arzmann, Petra Korenjak, Franz Rauch (IMST network), Andrea Frantz-Pittner (NEP) as well as review and validation by other LINKS members.

Guiding Principles for Networks and sustained Alliances within STEM CPD

Networks within educational contexts have histories. Some start in the 1990s, as educational network researcher Franz Rauch writes, when policy makers launched systemic school modernization processes in Western Europe. The need for reformatory change due to the results of international students’ assessment studies (like the Third International Mathematics and Science Study (TIMSS) or the Programme for International Student Assessment (PISA) prompted new measures. In the wake of educational strategies like decentralization of the school system and augmented school autonomy, educational authorities in several European countries have increasingly started to delegate responsibilities to decentralized educational units. Hence, less steering from top-down generates a need for alternative coordination and enhancement of educational policies. Intermediate structures

such as educational networks started to develop to fill this structural gap. These networks take over functions traditionally assigned to educational agents like the ministries of education or provincial education authorities respectively (Rauch 2016). As intermediate structures, they are new agents that help to manage school autonomy and their multiple educational actors. Thus, they try to explore new paths in learning and teaching between individuals and institutions (Rauch 2013). Pre-service as in-service teacher training in the line of a continuous professional development for educators within Science, Engineering and Technology (STEM) were and still are a key area in the development of educational networks, as the LINK partnership illustrates. Hence, the crosscutting issues discussions gave us the opportunities to frame some of our shared and distinguishing basic principles of work. The Norwegian educationalist Per Dalin (1999) laid theoretical foundations for the analysis of networks. For the author, networks have informative functions that become visible in a direct exchange of practice and knowledge for teaching and schools. Even more so, networks serve as a bridge between practice and knowledge. Through networking, further opportunities for learning and continuous professional development arise as these activities are encouraged by all members, thus establishing the learning function. Furthermore, trust is a prerequisite for cooperation within a network (Müller 2008). It is the basis for the psychological function of a network, which encourages and empowers individuals. A fourth function of networks is the political function (see figure 1).

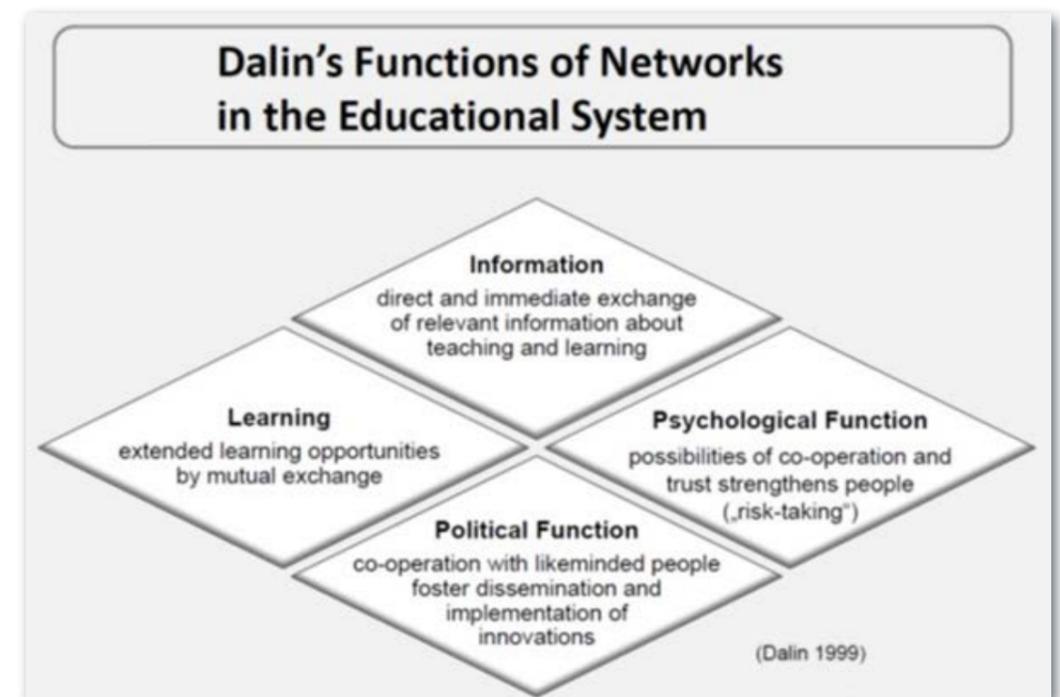


Figure 1: The functions of a network

Per se, networks can be permanent structures, or function as temporary stages in policy development. These networks can be formally or informally constituted, centrally managed or decentral. Moreover, networks may operate based on consensual decision making across multiple stakeholders.

However, educational networks do not exist for their own sake: they form around the following basic principles (Rauch 2016; EC 2018):

- Mutual intention and goals. Networks orientate themselves on a shared framework and horizon.
- Trust orientation. Mutual trust is a prerequisite for exchanging and sharing knowledge, and therefore a prerequisite for learning.
- Voluntary participation. Networks do not impose sanctions, interventions are rather mutually agreed upon.
- Principle of exchange. Mutual give and take of information, services etc. is vital. Challenges like an uneven distribution of power between actors and/or competition are addressed and dealt with.
- Steering platform. Networks are not occasional interactions, but institutionalized configurations. Network actors have to coordinate and maintain it in order to support exchange processes, cooperation, and learning.
- Synergy. Networks enable synergies through structural organization.
- Learning. Networks are support systems based on reciprocity. Those involved can exchange views and information, and cooperate on mutual concerns.

Thus, networks exchange skills, knowledge and resources for the mutual benefit of all involved. Moreover, networks may be distinguished from other forms of cooperation like clusters or partnerships. The ET2020 Working Group Schools describes clusters on the one hand as groups of people or things (e.g. schools) operating in a similar geographical area or field of work. Participants within clusters may share knowledge and resources, but are not necessarily working towards a shared goal or have established a common horizon of activity. Partnerships on the other hand are two or more groups that make an agreement to share knowledge, skills or resources, possibly during a period of joint activity (EC 2018). Partnerships generally include information sharing, program coordination, and joint planning. Two or more organizations get together and have a limited interaction, achieve a mutually beneficial goal like jointly planning an event or learning from each other. These cooperations may not be formalized in any way.

Even though the educational activities carried out by the various agents might be different, working partnerships surely are the cornerstone of thriving networks. What networks differentiate from partnerships is the interplay of diverse relationships, strengths of relationships and trust between active network stakeholders. Within a network, different types of actors get active, with some cooperating more closely. Networks bring together stakeholders from different sectors or different levels of the educational system (e.g. the scientific community and businesses, the rectorate, teacher training colleges and heads of schools). They usually exist for a broader support function and do not necessarily cease to exist after certain goals are reached (ibid.). A closer look into the workings of our five STEM CPD networks illustrates that the emphasis on various aspects of these basic principles is shifting (for further details see chapter two, three and four). The location the partners look at network functions from do make a difference. Chapter 1 therefore provides readers with an overview on the scope of the five LINKS network partners.



2

**How do we organize our
impact for innovative
STEM CPDs?**

This chapter introduces the LINKS partners and their respective networking agendas.

2.a In Austria, IMST and NEP play an intermediary role in their network activities

Within the LINKS project, the two institutions IMST and NEP represent Austria. These two are characteristic for the complex and dynamic Austrian STEAM-Learning community network (The A as extension to STEM stands for Arts) as they are two examples for the several national and regional networks for science education and science communication. In Austria, STEAM networks are often loosely connected through independent organizations with the main purpose of enhancing network thinking as well as network activity. Usually, single institutions are involved in several of these networks at the same time, while engaging in different cooperation programs. These networks usually do not form hierarchic relationships with each other; engagement and participation is based on the respective institution's own volition. Often, participation takes place during a certain time-period due to common projects. In this sense, IMST contributes to the LINKS partnership with perspectives of a nation-wide network structure, NEP adds its experiences of what it is like to work as an independent organization that engages in different STEAM networks as well as in other thematic network structures. IMST and NEP often collaborate with each other but none is part of the other.

Science Education Centre Graz (SEC) has a longstanding experience in the development and research of educational settings for science education. The institution acts as a site for out-of-school learning. It offers a broad range of didactic activities to support science teaching in all levels of education from kindergarten up to secondary school as well as for out-of-school groups. The institution is part of the national Science Centre Network and focusses on the cooperation between formal and informal learning as well as on the training of explainers and of teachers.

IMST is a nation-wide support system and network to provide quality based innovations in STEM and German education. For this purpose, teachers and teacher educators implement innovative school projects and exchange their experiences through networks. One reason for the success of the initiative is that IMST always strives for the cooperation of science and practice and develops conceptually based on changing framework conditions in the Austrian education sector. Colleges of teacher education and universities as well as schools collaborate within the so-called "thematic programmes", one of the two main-strands of IMST. Furthermore, the Regional Education Boards are involved in the "regional networks" – the second strand of IMST. These measures foster sustainable cooperation, which supports synergies in the educational systems (see e.g., Krainer & Zehetmeier, 2013). The IMST programme 'Regional and Thematic Networks' supports regional networks in all nine Austrian provinces (since 2008), and three thematic networks which operate on the national level. Within the IMST thematic programmes, teachers put into practice

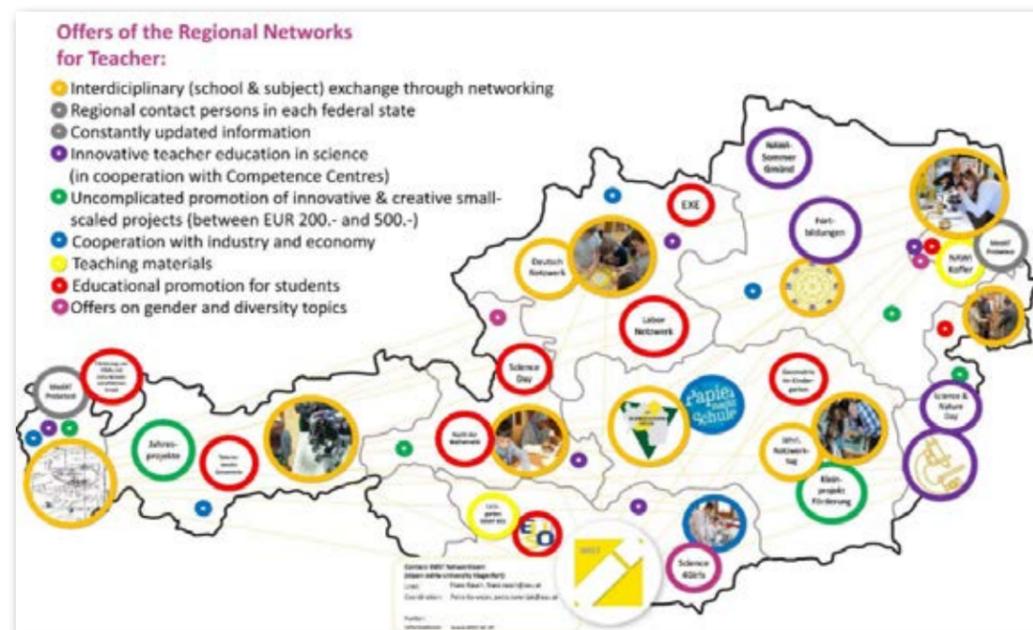


Figure 2: IMST regional networks

innovative instructional projects and receive support in terms of content, organization and finance. The goals of the IMST regional networks are manifold. They intend to raise the attractiveness and the quality of lessons in mathematics, biology and ecology, chemistry, physics, information technology, geography, descriptive geometry as well as other related subjects. Furthermore, they promote cross-curriculum initiatives and school development in grammar schools, vocational and secondary modern schools, even so in primary schools and kindergarten. They put a special emphasis on the professional development of teachers, while involving as many school forms as possible.

The formation of IMST regional networks is based on two principles:

- On the use of already existing personnel, institutional and material resources in the federal provinces
- All active persons act autonomously and take over responsibility for the development of regional networks

IMST as well as SEC see themselves as non-formal science learning structures and in their scope of work as intermediary educational structures.

2.b In Italy, establishing a network through international exchange and its devoted members

ANISN is a qualified institution for the training of teachers; it is authorized to set up institutional training courses for science teachers by the Italian Ministry of Education. ANISN fosters close ties to Universities and external research entities like MIUR. This means ANISN is able to organize and conduct initiatives for the identification and promotion of excellence in Italian schools. Since its foundation, it has worked in line with the National policy of the Ministry of Education aiming to improve and support the quality and dissemination of STEM education in Italy. Aware of the crucial role that teachers and science teaching in schools play, ANISN promotes a scientific culture that fosters students as science active citizens. ANISN's mission and activities

as a non-profit Italian Association is devoted to the improvement of CPD of STEM related subjects. During the last thirty years, thousands of committed members, mostly teachers themselves, have been organized in 26 local sections. These members represent the breeding ground in which necessary innovations of STEM CPD have been rooted and fostered in Italy. The key contribution of the International cooperations has been the adoption of systemic strategies, as well as the improvement of effective networking at various levels. All these factors have helped in the enhancement of the ANISN network, but they would not have been enough without the numerous persons who have assisted and assist others in the adaption and implementation of change. These vital members of the ANISN network have represented and still represent the necessary condition for the developments achieved so far.

There has been a continuous cooperation with the French Foundation La main à la pâte since 2009 as well as with other European reference centres for CPD on IBSE. These have been key for the continuing development of a network and its strategies. To date, 10 Inquiry- Based-Science-Education (IBSE) centres are the basis of ANISN's CPD network, spanning over Italy, as figure 3 illustrates. The European Fibonacci project (2010-2013) had a pivotal role in their coming into existence as the European experience helped ANISN to develop their CPD network. The cooperation with the "Accademia di Lincei", especially in the Fibonacci related SID programme, has proven to be a fruitful synergetic enrichment. The fruitful synergy is due to the sharing of different skills to obtain the common goal of improving the teaching of scientific subjects. Increased teacher motivation leads to meaningful learning experiences. All these exchanges and experiences have empowered ANISN to scale up their network.

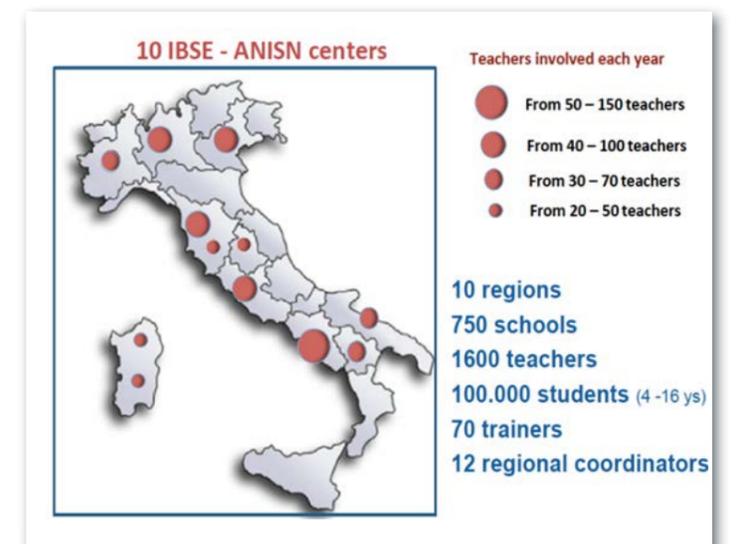


Figure 3: Geographical locations of ANISN Centres in Italy.

2.c In France, a strong partnership with the Ministry of Education at all levels

The national network of the “Maisons pour la science au service des professeurs” is a large-scale, multi-stakeholders endeavour for the professional development of teachers in STEM. The network was launched in 2012, for an initial duration of 7 years. During this period, 9 houses have been created within regional science universities (see fig. 4). Besides, the Foundation hosts the National Centre of the network. The creation of the Houses for science imply a strong partnership between the Rectorate (Regional Board of the Ministry Of Education), in charge of the regional implementation of the national professional development policy, the scientific university and the Foundation La main à la pâte. The Houses of sciences are situated at universities to guarantee innovative training, as well as their constant revitali-

zations thanks to public research contributions. The Houses offer a practical framework to develop a multi-stakeholder approach in developing STEM CPD, and in adapting to the needs and opportunities of each region. Rectorates in regions in France are crucial in terms of an operational implementation of all public education policies. While the regional Houses target mainly teachers – from primary and lower secondary levels-, the focus of the National Centre is on teacher educators and the production of resources. Moreover, the National Centre acts as the coordinator of the LAMAP network, ensuring the scope of the general frame, the quality of the activities and the building (and possibly scaling up) of the network based on the exchange of best practices and experiences, (this process is termed capitalization). At local level, the network has developed due to the inclusion of pre-existing structures. They are known as “La main à la pâte pilot centres” and are now associated with the LAMAP network as well as with the new satellite centres.

Figure 4: the Houses for science network



2.d In Finland, LUMA centres organize CPD

LUMA is an abbreviation standing for natural sciences (LUonnontieteet) and mathematics (MAtematiikka), internationally it stands for STEM fields of study. The LUMA Centre Finland network aims to bring science, technology and mathematics closer to children and youth by transforming the latest findings from science education research into practices and materials that make these subjects more interesting and motivating for young people. Another main goal is to support the life-long learning of teachers from early childhood education to university level, and to strengthen the development of research-based teaching.

LUMA Centre Finland is an umbrella organization that constitutes of 13 regional LUMA Centres (see fig. 5 above). LUMA Centres are located in Finnish universities and university campuses and the existence of the national LUMA network strengthens and promotes their collaboration on a national and international level. Each of the LUMA centres covers a certain region of Finland with the aim to supply the whole country with STEM CPD. Regional LUMA centres function as the link between university research and local education practices though providing a variety of STEM related activities and programs aimed at both young people and teachers. All activities provided

are based on research. Furthermore, they were designed to improve teaching methods. The LUMA Centres are collaborative networks that consist of professionals, researchers and students. Through scientific papers, CPD, different events and study visits, LUMA Centres distribute teaching models developed in their network.

The sustainability of LUMA Centre Finland is based on the cycle of continuous development, research and distribution of knowledge. Because all partners of the organization benefit from the development, the sustainability of the network is in everybody's interests. LUMA Centre Finland and the regional LUMA Centres cooperate closely with companies and the Ministry of Education. The aim of the cooperation is to raise the attractiveness of science, technology, engineering and mathematics (STEM) education in promoting STEM-related career choices among young people. This way, the LUMA network Finland contributes to the needs of employers and employees in scientific and technological fields. Starting in the year 2017, LUMA Centre Finland has received so-called "national task" and funding to implement it, from the Ministry of Education and Culture. Hence, the value of the network and the education provided is acknowledged nationwide by authorities, which indicates that the network and related activities are fostered. Essentially, LUMA activities are supporting teachers' CPD through novel research-based materials.

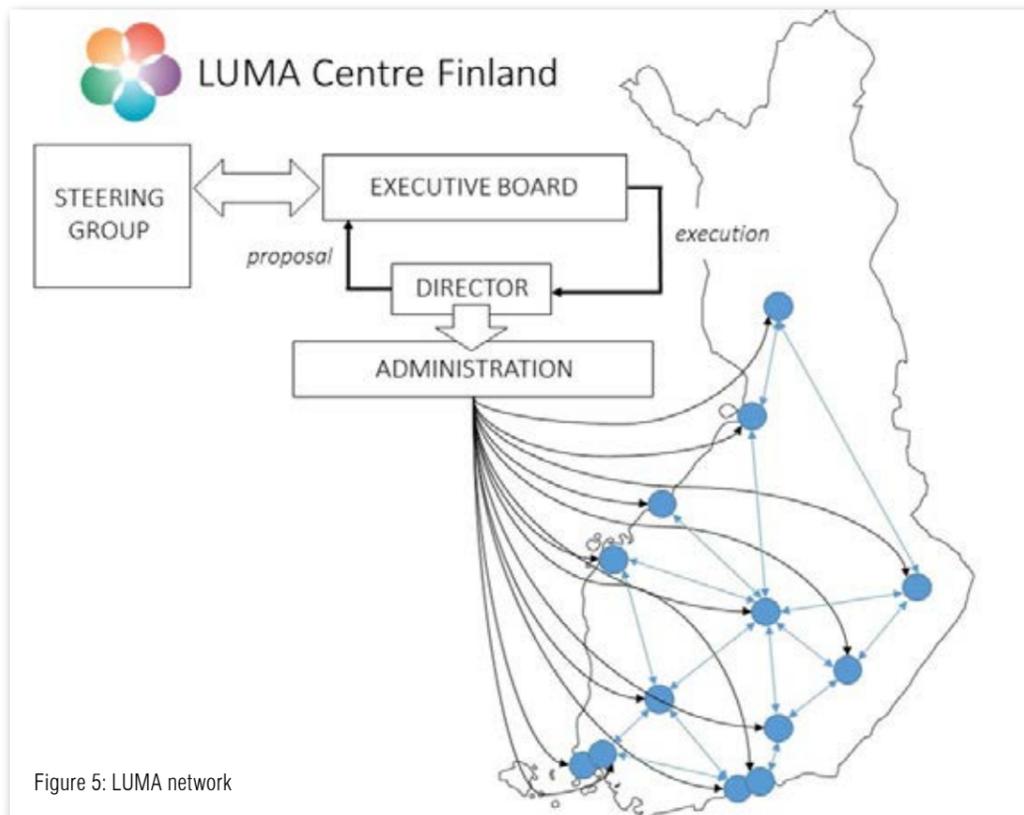


Figure 5: LUMA network

2.e STEM Learning in UK: partnering up to the challenge

The National STEM Learning Network is the largest provider of STEM education and STEM careers support to schools, colleges and other groups working with young people across the UK. The Network is dedicated to raising young people's engagement and achievement in STEM subjects, and to increasing the numbers progressing in STEM studies and into STEM-related careers. Additionally, STEM Learning enables teachers, technicians and others working with young people to engage with STEM-subject specific, career-long continuous professional development (CPD). For this purpose, the network provides free online resources, based on the national curriculum. Moreover, STEM Learning supports the STEM Ambassadors programme, STEM Clubs and a wide range of other STEM enrichment activities with proven impact on outcomes for young people. The Network is based at the National STEM Learning Centre at York, with state-of-the-art facilities for intensive teacher CPD and an extensive library and repository of resources in place. STEM Learning also stands for a network of forty-five Science Learning Partnerships in England, offering local access to subject-specific support. Nineteen STEM Ambassador Hubs across the UK link individuals and STEM employers with schools, colleges, and youth and community groups engaging in STEM. Thus, the Network reaches directly into every UK secondary school and FE College, and over 80% of primary schools. The STEM Learning network operates a wide range of activities in STEM education.

The National STEM Learning Centre also coordinates the STEM Ambassadors program – linking volunteers from a wide range of STEM backgrounds and disciplines with schools, colleges and informal educators who work with young people. STEM volunteers receive training and support to help them deliver effective and impactful activities by contextualizing STEM teaching, raising aspirations and challenging stereotypes. Yet another programme is the STEM Clubs network. It encourages schools and colleges to support vibrant STEM Clubs alongside other extra-curricular activities. Within the ESERO-UK programme, Space is used as a context to raise young people's achievement in STEM, including access to Space Ambassadors, resources, teacher CPD and events. In addition to improving the quality of STEM teaching and learning, the Network supports high quality careers education, encourages diversity, social mobility and equality in terms of access to good STEM education. The other cross-cutting themes that are embedded in many of their programmes are: -Building capacity, capability and communities of practice. Thus, STEM Learning helps employers and schools to develop long lasting relationships, in recognising and encouraging the career-long STEM-specific professional learning of teachers and technicians.

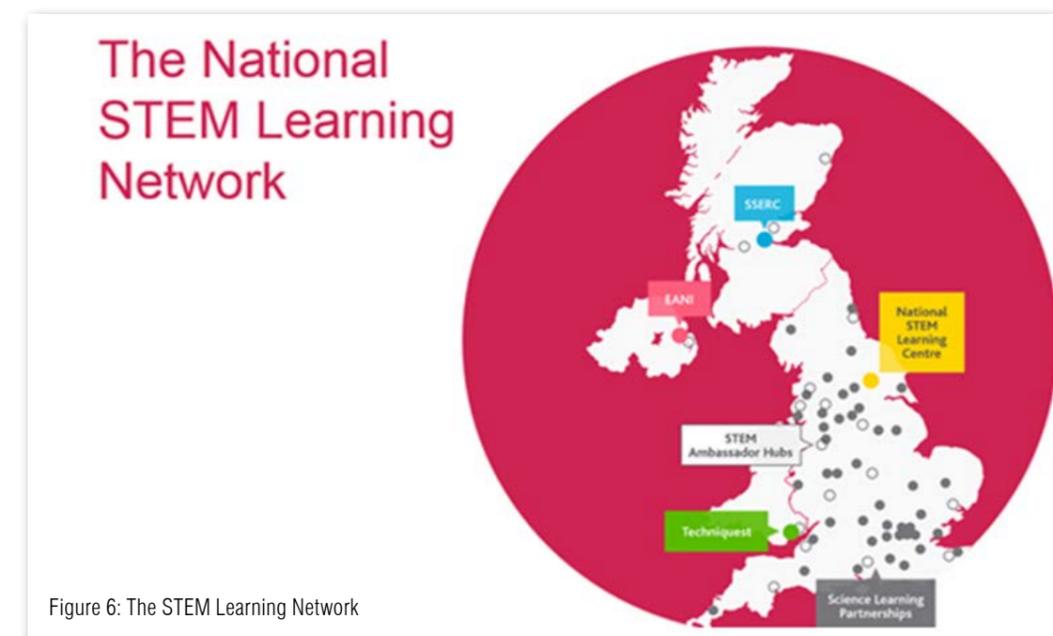


Figure 6: The STEM Learning Network

3

**Focused insights into key
network strategies**

This chapter maps out different networks strategies on how to broaden the impact of CPD activities. Some LINKS networks use specific strategies for their interventions into the education systems, be they specific organizational structures while working with educators or scaling up strategies of their CPD programmes. Certain elements seem to be common to all LINKS partners, even if timespans and timeframes of cooperation and modes of partnership vary. However, some are unique to national networks. This is why the given examples explicitly name the experience of the respective network.

3.a Enlarging the outreach through trust and a shared vision in education networks

Improving the quality and the fit of STEM education through continuous professional development (CPD) activities for teachers, remains an ongoing shared vision of all five partner networks within the LINKS partnership. To reach all aspects of school education, the CPD network idea does not follow hierarchical top-down strategies in the sense that educational authorities (e.g. Ministries) have to meticulously spell out educational strategies. On the contrary, the educational CPD network idea stands for more autonomy for various educational stakeholders at regional and local levels. Networks are a pathway to implement innovations in STEM teaching effectively and quickly. Working together and engaging in a learning culture enlarges the knowledge and experiences of everybody involved. There is an increased value placed on synergies, communication and collaboration (Krainer, Zehetmeier, Hanfstingl, Rauch, Tscheinig 2018). In order to connect vertically and horizontally in a way that every actor has the capacity to share, learn and make changes, building connections through trust and a shared vision is paramount. Working for a cultural shift to co-create CPD actions, instead of waiting for innovations to happen, is central to the LINKS partners.

For the ANISN network (IT) that meant establishing relationships of trust and transparency in the actions. A marker for the success of this approach is the gradual expansion of the network due to numerous schools joining ANISN over the last decade and keeping those relations.

These partnerships with local educational institutions are vital. Those responsible for local ANISN/IBSE centres and school leaders regulate

these relations through written agreements. Often these agreements are annually renewed due to changes that may have occurred. For some partnerships, national agreements have been stipulated together with other local agreements. In some cases, partners of the ANISN network provide rooms and laboratories to carry out the CPD activities, while in other cases, experts and materials have been made available to deepen the various topics, such as issues on the environment and the territory, health, scientific research applied to teaching and sustainability. The school leaders of the network have been active in involving their teachers by integrating the training activities proposed by the ANISN/IBSE Centres into the PTOF (Piano Triennale dell'Offerta Formativa/ Triennial Academia Plan).

In the case of STEM Learning (UK), one successful strategy is sharing their vision through sharing CPD knowledge on partners' conferences and vice versa. The staff of STEM Learning sits on many advisory boards with partners too, which fosters relationships as this improves trust and confidence in each other. The most successful relationships are built where priorities overlap and where there is a common vision, besides, common activities can help the deliverables of each partner.

3.b Working on joint planning committees and platforms for deliverables

Within the UK, there is a wealth of partnerships for Secondary Science e.g. with the Royal Society of Chemistry (RSC), there is joint support in the delivery of CPD. Additionally, STEM Learning hosts RSC resources on their website. Sometimes, members of the teams are on joint planning committees. This strategy is also applicable when STEM Learning works with the Scottish Secondary Education Research Centre (SSERC), where they share CPD delivery and ideas for courses to help meet local needs. For biology, the institution works with Science and Plants for Schools (SAPS) once again jointly delivering CPD and sharing resources. STEM Learning also works closely with the Institute of Physics (IOP) sharing resources and ensuring the two partners are sharing common messages on their CPD. One successful example of this is Improving Gender Balance, where STEM Learning's CPD lead trained with the IOP as a Gender Balance Champion and now uses these on courses at STEM Learning. There are also people on advisory boards for each of these organisations to help consistency

and prevent conflicting CPD from occurring. For Primary Science, STEM Learning works closely with CIEC, (Centre for Industry Education Collaboration) to develop and deliver CPD. They also produce resources, which the partnership highlights and shares with participants on CPD. STEM Learning's main partner is The Wellcome Trust. They have been working in collaboration over the development of their Explorify resource for Primary Science. STEM Learning also supports Primary Science Teaching Trust, PSTT, The ASE and Primary Science Quality Mark, and PSQM, by highlighting their resources and sharing them widely. This strategy of sharing CPD materials and the hosting of resources ultimately widens the reach of all partnering organizations.

In the case of the Houses of Science (FR), different areas of cooperation are a shared interest: CPD, which discusses issues of science and society, the scientific culture or equal opportunities. Partnerships with organizations active within these areas of education are formalized by conventions, for example with the universities or the rectorate. Subsequently, other agreements may be established with other higher education institutions, with local partners (CCSTI, CANOPE, etc.) and local industrial partners (large groups, local industries, etc.) The Houses of Science's attachment to a regional university allows a direct link to public research laboratories and gives access to a pool of researchers and teacher-researchers for the co-construction and co-animation of professional development actions.

3.c Collaborating with local initiatives to become national CPD centres

In the UK, sharing a common vision impacts the standing of network partners; for instance the cooperation with the University of York computer science department, which then became the CAS (computing at school) regional centre. The University found and recruited lead teachers (known as CAS Master Teachers) who STEM Learning worked with, developing their CPD leadership. STEM Learning also built a partnership with the Raspberry Pi Foundation hosting their CPD and resources, and highlighting the online offer of the respective organisations. Other partnerships, involving small scale or occasional collaborations, exist with several other organisations. In November 2018 STEM Learning, alongside Raspberry Pi and the Chartered Institute for IT (BCS) have partnered up to become the National Centre for Computing Education which has bolstered the sustainability of each organisation.

3.d Dimensions of Public/Private Partnerships: internal and external cooperation

For the establishment and proper functioning of a **House for Science** (France), partnerships are of crucial importance. They should guarantee a good interconnectedness of the territory, complementarity of the resources as well as the financing of the project. The House of Science distinguishes partnerships into two categories: public and private partners. Designed as prototypes in the service of a revitalization of the in-service training of teachers, the Houses for Science are located close to major university centres. Their purpose is to be a place of living science. In addition to training activities, this partnership with universities and higher education institutions makes it possible to offer other types of professional development actions: collaborative research projects (example : Ecolab). Researchers, research professors, and science students involved in the House of Science's professional development actions bring their scientific and technical knowledge and skills to the co-created and co-organized actions. Within higher education institutions, the ESPE (Higher Schools of Teaching) are privileged partners. Certain Houses for Science are incorporated into these. Each House for Science bases their public partnerships on good relations with the Academy, Rectorate (in charge of the regional adaptation of the national professional development policy), Universities and other higher education institutions. The rectorates provides financially for a large part of actions included into the academic training plan. They also reimburse travel costs and lunches for secondary schools. The rectorate is also consulted for future CPD offers as well as for the joint design and implementation of trainings. Some Houses have developed strong links with the ESPE (teacher training colleges). Various public structures may also be involved depending on the region and depending on the specificities of the Houses for Science: These could be communities of universities and institutions, research organizations, local authorities, associations and so on.

The second type of partnership to establish for the territorial anchoring of the House for Science is the link with the local industries and more generally the companies, as external partners. At a time when school to business interactions in France are still marginal, Maisons pour la science have initiated several partnerships to introduce various scientific and technical professions to teachers. Due to these cooperation's, the Houses of Science are able to shed light on science in the workplace and in industrial processes. A House for Science can organize conferences and seminars dedicated

to industrial partnerships to publicize its action to the local industrial fabric and develop new partnerships with companies. To date, there are three types of sponsorship: First, skills sponsorship (participation of company employees in professional development actions, company visits, etc.) Second, there is the donation of material and equipment and third, there is financial sponsorship.

3.e Organizational Steering Strategies of the networks

LUMA Network (FI): steering of a national mission through coordination and advisory boards

On a national level, the Board of the network coordinates the activities of the LUMA Centre Finland. The Board has a representation of all the participating universities around Finland, and as such, it can engage all the regions of Finland in the activities. The Board manages the prerequisites for the operation of the LUMA Centre Finland and verifies the common strategy, the action plan and the budget of the network. Furthermore, the Board steers, and supports the work of the Director. It also accepts the annual report of activities of the network.

In addition to the Board, national steering takes place through the National LUMA Advisory Board. The Advisory Board serves as the guiding conversational forum for the Board of the LUMA Centre Finland. The Advisory Board constitutes of approx. 30 partners, thus marking an exceptional national cooperation of different stakeholders. These include for example a wide representation of the Finnish trade unions of teachers, museums,

research institutes, the Finnish National Agency for Education, media, industry associations and other business sector, National Matriculation Examination Board and other various organizations and unions with an interest in STEM education. To ensure that we reach our aims, the Board as well as the Advisory Board meet regularly. For the networking and the partnerships that we have built, we consider especially the meetings of the Advisory Board to be pivotal – by giving the participants a possibility to present their viewpoints and wishes regularly their participation becomes meaningful, and the LUMA Centre Finland gains important viewpoints from various fields.

An important factor in LUMA Centre Finland's operation is the existence of a national strategy that defines the aims and objectives. In addition to this, the Finnish Ministry of Education and Culture has assigned a national mission for the LUMA Centre Finland. The national mission includes six sectors, one of them being the CPD of pre-service teachers and in-service teachers and the development of new models for carrying out the CPD. In this mission, it is believed that strong connection to the training of pre-service teachers is vital. This is accomplished as the LUMA Centres are borne by the universities that oversee the training of new teachers.

IMST (AUT): coordination through a clearly negotiated and structured horizontal process

As an Austrian-wide initiative active for many years, IMST involves a broad network of partners in improving STEM teaching on many levels. The fostering of the IMST regional networks, the founding of the regional specialized didactics centres (RECCs) as well as a large number of educational and school projects (see IMST Wiki) within the thematic programmes emerged over these years.

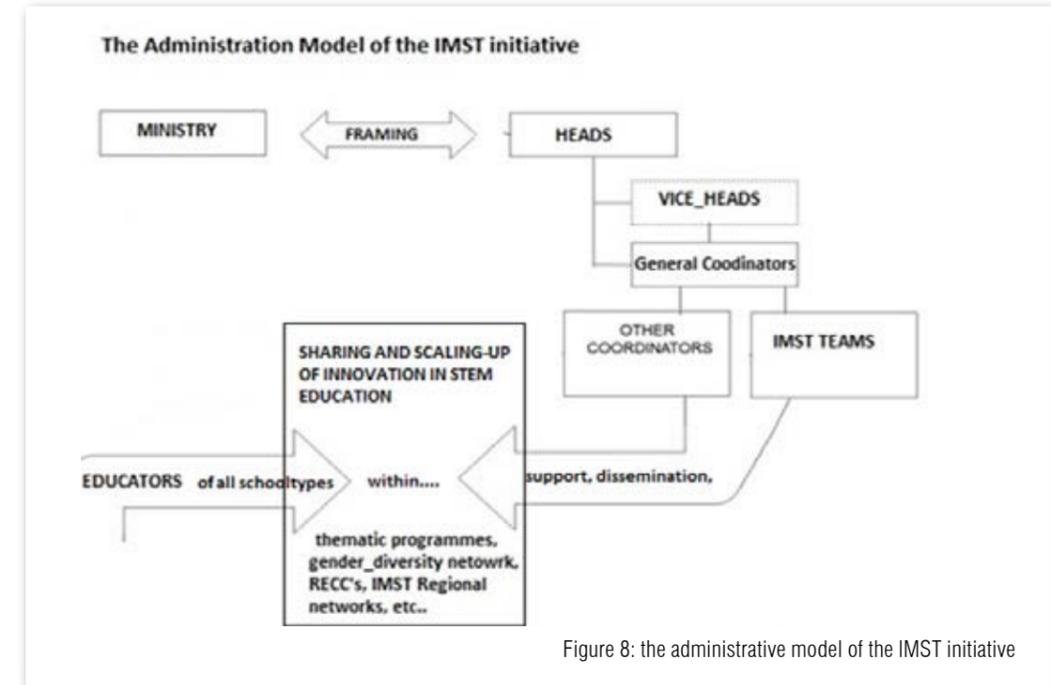


Figure 8: the administrative model of the IMST initiative

The Institute for Instructional and School Development (IUS) at the Alpen-Adria-University Klagenfurt coordinates these activities. The heads of IMST are Konrad Krainer, Heimo Senger as well as Franz Rauch and Barbara Orasche (vice-heads) who all work for the department as professors, researching practitioners or science communicators. The heads of IMST take part in regular meetings with the ministry of education to negotiate frameworks for current and future developments. The cooperation between the Austrian ministry of education and the University of Klagenfurt is designed in the form of an inter-municipal cooperation. As part of this cooperation, the IUS is responsible for the strategy, the steering and the coordination of the entire IMST initiative. The national IMST steering group consists of the head coordinator of the network programme, the head coordinator of evaluation, the head coordinator of science communication, the head coordinator of the thematic programme, the head coordinator of finances as well as the head coordinator of the IMST gender_diversity network. Each coordinators cooperates with their respective teams and/or affiliated coordinating persons at different universities, teacher trainings colleges, regional educational didactic centres and schools throughout Austria. Twice a year, all affiliated IMST members active within the regional network, the thematic programmes and in research meet with the general coordinators and the heads of IMST for a network meeting on the future strategies of the network. These take place in a seminar hotel and last for two days, filled with input, general discussions and subgroup-meetings. IMST's main idea is to cooperate closely and at eye level with all CPD

providing partners. Therefore, members of IMST engage in communication and planning across the usual hierarchic levels at universities, schools, teacher trainings colleges, regional educational policy makers and out of school learning places.

3.f Scopes and timeframes of interactions

On a structural level, the timespan and timeframes of cooperation and partnership vary. This applies to partnerships and established relations with CPD providers within the networks, but also to the forms of CPD programmes offered for teachers through the LINKS partners.

The ANISN IBSE Centres for example manage:

- continuous and well established collaborations (with different typologies of joint actions),
- periodic collaborations (1- 2 CPD seminars every year),
- Occasional collaborations (one or more CPS on a specific topic).

The various collaborations take place with University professors or with experienced teacher trainers of the different school types. Research experiences are shared on the activities carried out with our students with other less experienced teachers. Basic training is carried out with new teachers, while with already trained teachers, activities are shared and expert tasks are created.

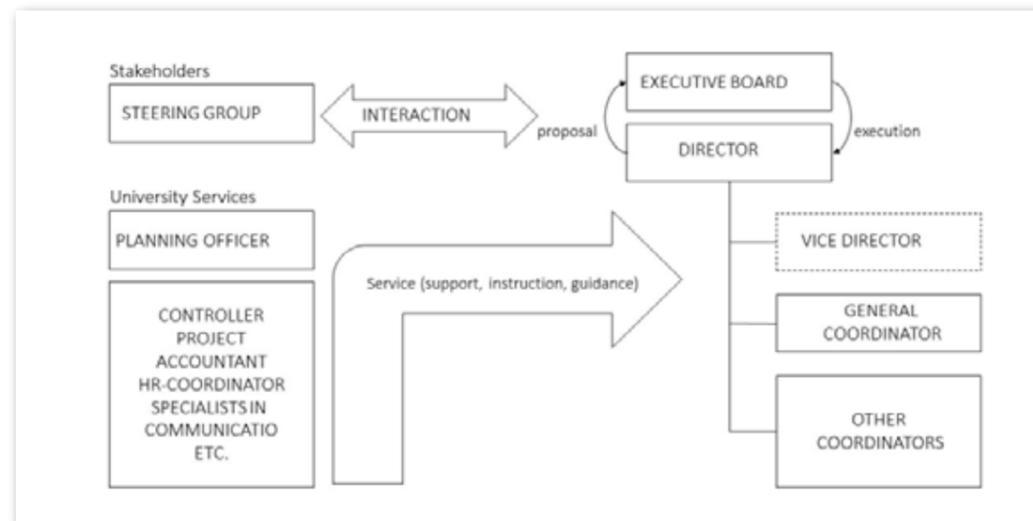


Figure 7: Administration model of University of Helsinki Science Education Centre

Some initially occasional collaboration have been turned into collaborations of longer duration thanks to the creation of interpersonal relationships based on respect and mutual interest in STEM fields of education. Successfully building relationships of trust helps to prolong shared activities.

Scopes and timeframes vary if the CPD is part of the regular schoolwork or if teachers commit to these in their free time, as the French example illustrates. The **French House for Science in Midi-Pyrenees** offers different types of professional development actions, depending if they take place during school time or during holidays, with significant consequences for the target group. During school time, these actions are part of the official training plan and teachers are only eligible for a CPD programme by the House for Science after validation of their hierarchy. The duration of the activities may span from one to several days. In addition to these CPD programmes, the partnership with the National Education Authority allows the development of different types of projects during school time. These strive to be interdisciplinary (e.g. Let's Go: «Science in English»), to address issues like equal opportunities (e.g. Handi' Science: «Science and Disability»), or to guide teachers through the process of teaching science and technology (e.g. Scientific partners for the class – Partenaires scientifiques pour la classe). Here, teachers receive special support from one or more scientists or science students. Out-of-school professional development actions are offered during school holidays. Interested teachers register individually and voluntarily with the Houses of Science. These courses last one or more days and are focused on the development of scientific culture (Nature of Science). Therefore, they address more transversal issues and are organized on noteworthy scientific sites, if possible. Whereas these activities take place in the free time of teachers, the CPD on school time is part of the regular work schedule and basic costs like travel and lunches are reimbursed. The latter surely is a better incentive for professionalization processes; the former is a good incentive for curious science teachers.

IMST Regional Network (AT): Concentrated communication channels of intermediary actors

The example of the Regional Networks of the IMST initiative gives a rare insight into the temporal and spatial workings of a CPD network. Until 2018, the support structure of IMST was divided into a network program and several thematic programs. Within the network program, IMST supports regional networks based on specific target perspectives and on shared development agreements. In the context of regional development approaches, the IMST regional networks have the opportunity to promote «district networks»,

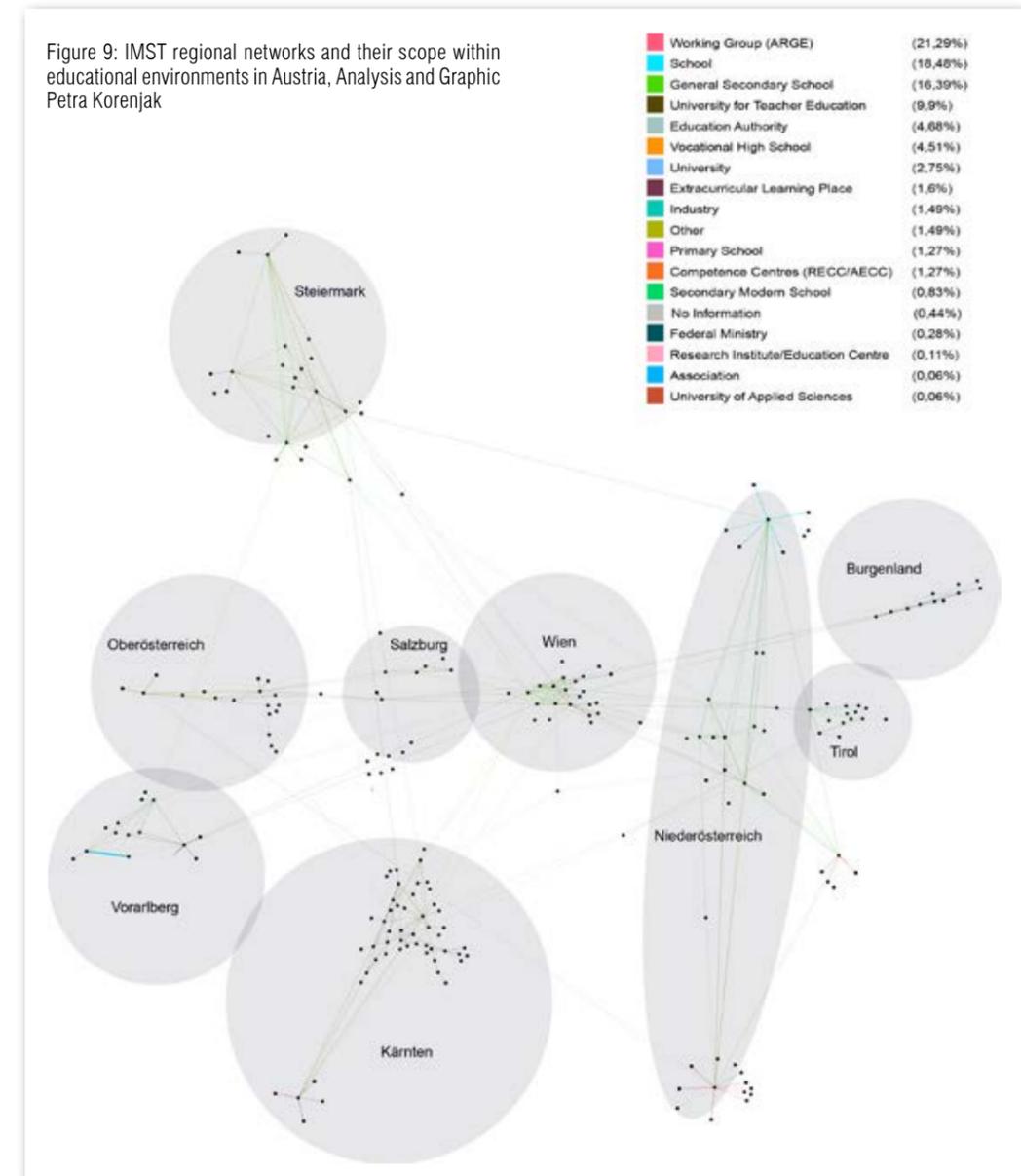
«regional subject didactics centres», «subject groups in schools», «networks between schools» or other regional or local initiatives. Founded in different years (see graph below), their duration is officially in parallel with the IMST initiative, meaning every third year, there are negotiations with the Austrian ministry of education for their prospective prolongation underway. Moreover, every year, these networks have to hand in reports of their activities to the IMST coordinating group.

The IMST national network coordination at Klagenfurt university 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 participate. Most of them are teachers and representatives of other institutions. The size of the steering group exceeds the number ten persons. A person from this regional group coordinates the steering group (regional network coordinator) and is the contact person for IMST's national network coordinator.

The current research project titled «IMST Social Network Analysis» by Franz Rauch and Petra Korenjak (2017-2019) analyses the spatial and temporal aspects of network communication within the IMST regional networks. By mapping the interactions of IMST network actors, this research intends to illustrate the processes of communication and cooperation among IMST regional networks regarding their scope and frequency. The study uses an egocentric network model, focussing on individual actors (nodes) and their scope of connections in the IMST network. This positional approach, which is limited to the micro-level, allows for statements about the actors' role within the network structure, the frequency and addresses of communication processes, as well as the fabric of group relations. Preliminary findings show the most frequent communication processes take place within the various regional networks. This may be explained by the pursuit of common goals and concrete regional activities of the steering group. Thus, the communication contents are framed by appointed key activities. The internal division of roles in organizational processes in the network also get visible in those maps (see figure 9). The graphic below illustrates these links and contacts of the regional network steering group members with their communication partners. First, there is the most intensive and frequent contact with other members of the steering group in the respective federal states. In some cases, there are also links to people in other states in connection with certain projects and due to the exchange of information among steering group members of different IMST regional networks as well as further educational networks. Second, the chart illustrates the institutions involved in the communication processes. It is noteworthy that some network

actors work at several CPD institutions at the same time, 8% of the actors work for two institutions, 2% even for three institutions at the same time. Third, the most frequently mentioned cooperation or communication processes in the survey take place between working groups/consortiums and schools of all grades and types. This is due to steering group members who are significantly involved in working groups and thus have many contacts to teachers. Their main task is to disseminate information to actors responsible for STEM education. Four, apart from that the most frequent exchange is established between the target groups General secondary schools, Universities for teacher education, Education Authorities, Vocational High schools and universities. Depending on the federal state, the intensity of

further communication with partners of extracurricular learning sites, businesses and industry, regional educational didactic centres or primary and secondary schools varies. In the regions of Carinthia and Vienna, communication and cooperation with non-formal and informal learning sites are mentioned more often. These are institutions such as the NAWImix - Lakeside Park Lab, the Science Centre Graz, the Future Learning Lab Vienna, the initiative Young Science, the green lab, or the Science Centre Network amongst others. Looking at businesses and industries, organizations such as syn2value, the Federation of Industrialists or Austropaper are mentioned. Especially the regional network in Styria developed close ties to businesses and industries for enhancing their CPD and surely are role models when it comes to initiating those ties.



4

**How do we counter
challenges in STEM CPD?**



This chapter gives an overview on European challenges in providing STEM CPDs. Which difficulties do LINKS partner encounter and how do we address them?

4.a Maintaining a life-long learning agenda in science education

Being an intermediary agent, LINKS partners work as a catalyst between different organizations. The aim is to bring people together to achieve common goals. Usually, most of the challenges educators and policymakers encounter are due to a lack of dialogue and connections. Intermediary education networks act as the integrative agent between schools, corporations, policy makers and researchers. The education policy makers set the goals for STEM education, and networks may support them in reaching these goals by assisting teachers to adapt to the changes through CPD, new models and materials. Furthermore, CPD networks provide policy makers with new research findings to consider when making decisions.

One of our main challenges is to maintain a life-long learning agenda in science education. Around this issue, network partners constantly develop new learning models in cooperation with the Ministries of Education.

4.b Broadening partnerships regionally

The potential for scientific partnerships at the major regional university centres is immense. It is not always easy for LINKS partners to identify all the individuals who could participate in their professional development actions. Similarly, the entire Scientific Community does not yet unconditionally embrace the cooperation with CPD networks. Our goal is to deepen networking activities with universities and higher education institutions regionally. The instalment of a scientific director, an advisory board with local scientists and all relevant partners would facilitate these steps. Generally, the activities of CPD networks may contribute to the promotion of research, enhance policies of continuous professional development at universities, and contribute to the development of scientific and technical culture. LINKS partners see these as key elements of their societal commitment. The development of partnerships with the industry is strongly dependent on the nature of the local businesses, their specializations, their innovative character or the size of the company. Very few companies are aware of the potential of shared CPDs for their development.

4.c Navigating conflicting needs in partnerships

A challenge lies in the communication and coordination of all different partnerships that form the basis of a CPD network. Another major difficulty is the conflicting needs that come along with these. LINKS partners address conflicting needs by being realistic about partnership expectations, by meeting regularly, and by ensuring that everyone knows what is required of them, and when. Nevertheless, this approach still needs to be followed up, as it can fall off peoples' radar. Where competitors have similar offers, then one possible approach is to look at the strengths of each partner in order to combine these to prevent double funding. A good example of this is working alongside the Institute of Physics (IOP) where STEM Learning delivers the course and the IOP uses their expertise to lead sessions on these courses with some of their presenters.

With funding streams being reduced due to austerity, sustainability is a key issue. LINKS partners are eager to ensure there is no repetition between organisations. CPD partners lead where they have their strengths and support the other partners in areas where they have a stronger offer. This makes CPD more sustainable and allows organisations to learn from each other and build and grow.

4.d Intermediate through challenges over time

Established to better connect practitioners with innovation and cutting-edge scientific research in STEM, CPD networks do not only act as intermediaries in a rapidly changing educational landscape, they also balance bottom-up policy needs with top-down policy steering. Moreover, they are forums for formal and informal learning, informed by recent scientific research. However, they also have to outlast alternating modifications in policy planning and goal setting. Since large-scale and long-term education initiatives require both flexible plans and the use of windows of opportunity, it is paramount to respond creatively to these challenges. However, the challenge posed to networks by the uncertain financial situation may also present opportunities for an ongoing broadening of perspectives. In Austria, for example, a wide variety of alliances and cooperation were formed to implement development projects in the STEAM area. The need to acquire additional funding sources lead to very heterogeneous networks that combine science education with other social contexts such as art, regional planning or social research. Thus, a number of networks support STEAM education at different levels and are closely interwoven with each other. Together, they often succeed in acquiring alternative funding channels.



5

**Key recommendations
for networks and policy
makers**

Agenda

- Start with the teachers'- and students' needs! By regarding educators as experts of change and by giving educators the opportunity to build on their specific contexts, to broaden their autonomy, to do it critically and in relation to a group of peers is one of the engines of CPD networks. Self-critical reflections of professionals and researched based support by external experts should come together in these efforts. Regional centres and networks, near the working place of teachers and teacher trainers, increase the likelihood of sharing experiences and of disseminating innovations.
- Share knowledge and objectives internationally in order to improve scientific learning! This remains a key factor for the success of LINKS partners and we highly recommend pursuing this goal.

Directions for cooperation

- Cooperate with policy makers: during the planning, implementation, and evaluation of the initiative! We consider the successful involvement of various stakeholders to be a key strategy. One of the keys to the well-working cooperation is planning and following the cooperation and its' results together: clear aims should be set and regular meetings arranged. We consider close cooperation with the Ministry of Education as beneficial and important for being able to develop education at schools. For example: Carrying out numerous tasks of the Finnish Ministry of Education and Culture naturally aids in building good relationships with national, regional and local authorities.
- Cooperate with different universities, link research to CPD (including pre-service level)! We consider structures based at universities as beneficial: the collaboration with scientists and experts happens naturally, and activities can be linked to pre-service teacher training. Furthermore, carrying out research on everything we do ensures that our activities are not quick "tricks" with no long lasting effects or clear purpose.
- Cooperate with business life and other stakeholders! This aids in ensuring that the education stays relevant for work-life. Businesses are often better on track with new inventions than schools, such as artificial intelligence, and they are already requiring the 21st century skills from their employees. We

also recommend integrating other socially relevant actors, such as communities, artists, citizens' initiatives into the networks. As such, this cooperation helps us bringing these concepts into schools. This aids us in enhancing the personal, vocational and societal relevance of science, technology and mathematics to students.

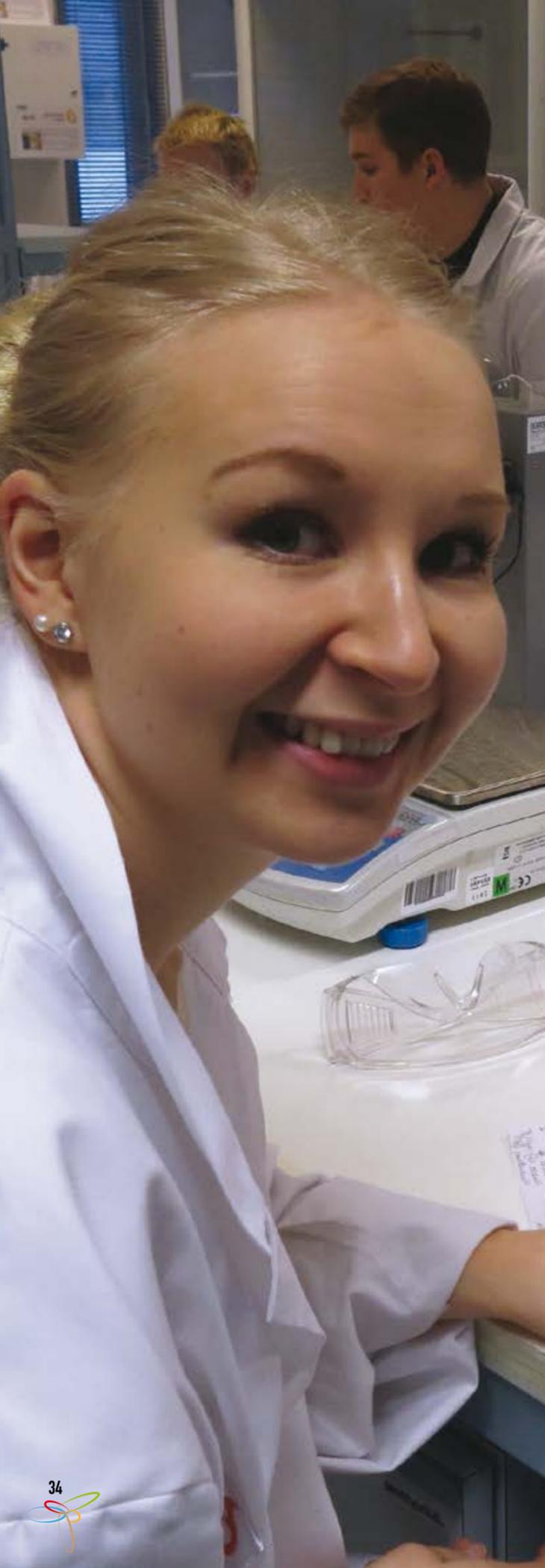
Organization and Formats

- Involve various stakeholders in advisory boards! Social responsibility and better visibility in the employment area are motivating levers to engage companies in CPD networks. Hereby it is vital that all parties share their strategic goals to ensure everyone is on the same page, thus avoiding crossover and conflict. We consider the successful involvement of various stakeholders in Advisory Boards to be a key strategy. As our networks have developed partnerships, the reach and impact has improved and partners reach significantly more teachers than they would be able to, if they worked in isolation. This also allows partners to leverage skills and knowledge that they might not have within areas of their organisation.
- Engage stakeholders in process planning and evaluation! We consider the presence of the funder in the whole process as pivotal; this way the funder can see what has been done and how they benefit from it. Evaluation of how objectives have been reached should be done together too, at the start of the cooperation, midway through it and at the end of it. When the checkpoints and evaluations have been agreed upon, the quality of the cooperation remains satisfying for both parties. The support of the educational policy makers in kind or in cash is a guarantee of the durability of CPD activities.
- Bring policy makers, universities and teachers to one place in the form of CPD during a national collaborative event! The annual National LUMA Days is an event that brings everyone involved in science, mathematics and technology education together for 2-3 days. So is the IMST day each year in May and the IMST seminar in September. Within these events, teachers join workshops, presentations, pedagogical cafes for discussions, and business visits to partner companies. Furthermore, the meetings of the LUMA Board and LUMA Advisory Board usually take place during the LUMA Days, as all key stakeholders are at the same place at this time.





**Building comprehensive
alliances and
partnerships for
sustained CPD!**



Innovation in STEM education requires an understanding of policy makers for the purpose and nature of networks. Moreover, it is advisable for policy makers to be part of a STEM CPD network themselves and to support them adequately in their development.

An ideal cooperation would be a common development programme with the Ministries for Education and regional educational authorities that would include common planning through a common steering group. The needs and aims should be planned together. Additionally, all partners should closely follow the implementation of the programme. This could enhance the activities carried out by networks. The LINKS partnership believes it to be paramount to combine bottom-up based innovations by teachers with top-down elements of educational steering. This translates 1) into building on the autonomy of educators and their motivation to pursue their continuous professional development in STEM. And 2), to focus and steadily develop the schools' responsibility to take part in STEM CPD activities as they bring new elements like cutting edge scientific knowledge, educational standards, equal opportunities measures, or new findings in subject didactics into the school system (Krainer et al. 2018).

In complex school education systems, networks are a stimulatory approach to the

- Support of horizontal decision-making
- Complex problem solving
- Revitalization of intervention/research approaches in schools
- Creation of synergies between stakeholders
- Enhancement of the professional development of teachers
- Support of capacity building in schools
- Mediation between different levels of the school system
- Despite our challenges, networks have the potential to co-create more sustained and comprehensive futures.

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Photographic credit:
LINKS

Published in May 2019 by the Foundation *La main à la pâte*, 43 rue de Rennes, 75 006 Paris, France



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The LINKS project is coordinated by



Partners of the project



This project is funded by the Erasmus + Programme of the European Union.