

This is a self-archived version of an original article. This version may differ from the original in pagination and typographic details.

Author(s): Myllymäki, Mikko; Impiö, Pentti; Hakala, Ismo

Title: Collaboration network for inspiring children and youth into science, mathematics and technology in Finland

Year: 2021

Version: Accepted version (Final draft)

Copyright: © 2021 IEEE

Rights: In Copyright

Rights url: <http://rightsstatements.org/page/InC/1.0/?language=en>

Please cite the original version:

Myllymäki, M., Impiö, P., & Hakala, I. (2021). Collaboration network for inspiring children and youth into science, mathematics and technology in Finland. In D. Maga, & J. Hajek (Eds.), Proceedings of the 30th Annual Conference on European Association for Education in Electrical and Information Engineering (EAEIE 2021) (pp. 71-75). IEEE; Czech Technical University in Prague. Proceedings of the International Conference on European Association for Education in Electrical and Information Engineering. <https://doi.org/10.1109/EAEIE50507.2021.9530931>

Collaboration network for inspiring children and youth into science, mathematics and technology in Finland

Mikko Myllymäki
University Consortium Chydenius
University of Jyväskylä
Kokkola, Finland
mikko.myllymaki@chydenius.fi

Pentti Impio
University Consortium Chydenius
University of Jyväskylä
Kokkola, Finland
pentti.impio@chydenius.fi

Ismo Hakala
University Consortium Chydenius
University of Jyväskylä
Kokkola, Finland
ismo.hakala@chydenius.fi

Abstract—the importance of STEM education is widely recognized. Despite the value of the sector and good associated employment prospects, young students generally lack interest in science and engineering. This is reflected in the difficulty universities experience in recruiting qualified students for STEM subjects, which in turn is reflected in business life and is a factor slowing down countries’ economic development. In Finland, efforts have been made to solve this challenge by launching the LUMA Centre Finland network, which consists of 13 university-related centres promoting STEM issues throughout Finland. This paper describes the network and its objectives, with a special focus on the activities and good practices of the LUMA Centre of Central Ostrobothnia.

Index Terms—STEM, science education, mathematics, technology education, engineering

I. INTRODUCTION

There is a growing need in society and business for people with adequate scientific, technical, engineering, and mathematical skills—so-called STEM skills [1] [2] [3] [4] [5] [6]. STEM education refers to teaching and learning in these fields. Promoting STEM education is an economic necessity in virtually all countries, with both developing and long-established economies [6]. STEM education can be seen as an educational philosophy in which STEM disciplines are used as an integrative means to solve real-life problems [7], and it can take place in both formal and informal classroom settings [8]. STEM education includes activities at all school levels.

Learning about science involves the acquisition of integrative knowledge that can be used to understand natural phenomena and innovate new developments [9]. A key purpose of STEM activities is, in addition to providing conceptual understanding of science, the teaching of twenty-first century skills, such as problem-solving, creativity, collaboration, communication, and critical thinking [10].

Finnish young people have performed well in international comparisons of STEM [5]. Despite such success, these fields fail to attract sufficient numbers of young Finns to universities. The effects of this phenomenon translate to business environments since companies cannot recruit enough STEM experts to meet their needs. According to national reports, there is

an urgent shortage of technology and ICT experts in Finland, and this shortage of ICT experts is also reflected in many other sectors, such as health care, finance, and public administration [11]. The shortage of experts is significantly slowing down economic growth.

The foundation of STEM awareness is formed in early childhood, particularly in primary education. Such early involvement and good experiences of the topic can influence and stimulate interest in STEM subjects [12] [13]. It is therefore important that children and young people have adequate access to STEM initiatives and activities at an early stage, through which they can gain awareness of STEM subjects and an understanding of STEM-related professions. When teaching young students, teachers play a very important role regarding STEM subjects [13] [14]. It is therefore important that teachers also have sufficient experience and knowledge of STEM topics and, above all, positive attitudes toward it. To be effective, raising STEM awareness must not be limited to children alone, but must involve the whole field of education and both formal education and non-formal activities, such as science club activities.

In response to this challenge, the LUMA Centre Finland networking was launched, with 13 LUMA centres on Finnish university campuses (www.luma.fi/en/). The name LUMA is formed from the Finnish abbreviations of *luonnontieteet* (natural sciences) and *matematiikka* (mathematics); hence, the acronym LUMA closely reflects the term STEM. In fact, the European Union (EU) STEM Coalition ([www.stemcoalition.eu.](http://www.stemcoalition.eu/)) calls LUMA Centre Finland a Finnish STEM platform. The aim of the LUMA network is to increase interest in, and knowledge about, STEM-related topics in Finland, involving both students and parents. The LUMA network actively seeks to keep STEM topics at the forefront of social debate. Since teachers play a key role in the STEM-related experiences of children and young people, the organization supports the inclusion of STEM subjects in teacher education.

Each regional LUMA Centre promotes the organization’s national mission from a regional perspective, but there is a great deal of cooperation between centres. The LUMA

Centre of Central Ostrobothnia (luma.cinetcampus.fi) is a local organization coordinated by the Kokkola University Consortium Chydenius. The LUMA Centre of Central Ostrobothnia supports cooperation between schools, colleges, universities, businesses, and other related actors in Central Ostrobothnia Province. One of the centre's main activities is supporting STEM teaching in schools through new teaching methods, materials, and environments. Efforts have also been made to integrate STEM disciplines more effectively into the training of teacher students. In addition, the centre has organized science class activities in cooperation with the University of Applied Sciences.

This paper introduces the organization and objectives of LUMA Centre Finland, providing a detailed description of the activities of the LUMA Centre of Central Ostrobothnia, and highlighting some established practices for promoting STEM.

II. LUMA FINLAND NETWORK

The first LUMA Centre was established at the University of Helsinki at the end of 2003. A science education development project called the LUMA Program already existed, which was coordinated by the Finnish National Board of Education. A main goal of the national LUMA Centre was to strengthen LUMA operations throughout Finland; thus, since 2007, LUMA Centres have been established in connection with universities across Finland. In 2013, LUMA Centre Finland was established, which today acts as an umbrella organization for local LUMA Centres. Today the LUMA Centre Finland is a network organization, with 13 LUMA Centres on Finnish university campuses (www.luma.fi/en/centre/). The locations of the regional LUMA Centres are Helsinki (2), Joensuu, Tampere, Kokkola, Jyväskylä, Turku (2), Rovaniemi, Vaasa, Lappeenranta, Oulu, and Lahti (Fig.1). The organization is funded by the Ministry of Education and Culture.

The role of the LUMA network is to promote interactions between STEM actors and to create models of cooperation. Its aim is to raise the level and extent of mathematical, scientific, engineering, and technological knowledge in Finland. In practice, this involves increasing the interest of children and young people in STEM-related subjects in primary schools, with the aim of encouraging the uptake of these subjects in upper secondary and vocational education. The network also aims to raise parents' awareness of the importance and opportunities of STEM disciplines in working life and to increase the visibility of STEM in society. In addition, it supports the training of current and future STEM teachers and student counsellors. The LUMA network aims to influence virtually all actors in the STEM field: pupils, students and teachers at various levels of education, from early childhood education to university; children and young people outside school; parents of children and young people; and other actors in society, such as businesses and representatives of different communities.

Each regional LUMA Centre promotes the national mission from its own regional perspective, so the STEM-related activities of each centre may vary. There is significant cooperation

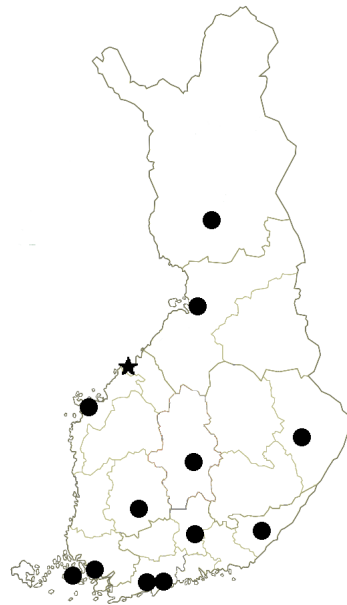


Fig. 1. Regional LUMA Centres. The LUMA Centre of Central Ostrobothnia is marked with a star.

between centres, and the coordinators of the centres meet regularly. Good STEM-related practices, experiences, and materials they create are openly shared and various networked teams support collaborative development.

Between 2014 and 2018, the LUMA network reached an estimated 385,000 people in the field of education and training (35,000 of whom were involved in actual activities and 350,000 through online communication); 750,000 children and young people with their families (250,000 and 500,000 respectively); and 55,000 other STEM actors (5000 and 50,000 respectively). The total number of people covered by the network was thus estimated to be 1,190,000.

The LUMA Finland network is an active initiator of, and participant in, joint development projects, of which research is often an integral part. In addition to the network's joint projects, the regional LUMA Centres have various ongoing research and development projects.

The LUMA Finland network also operates internationally. Cooperation is conducted globally with other science and technology education organizations, such as the Stage Europe network and the EU STEM Coalition.

III. LUMA CENTRE OF CENTRAL OSTROBOTHNIA

The LUMA Centre of Central Ostrobothnia (luma.cinetcampus.fi) is located in Kokkola, the capital of the Central Ostrobothnia region. This LUMA Centre is coordinated by the Kokkola University Consortium Chydenius. Many features of the area and the centre's resources and potential partners have contributed to the way in which the centre's activities have developed

A. Description of the Operational Environment

Kokkola is located on the west coast of Finland. The bilingual city has a population of almost 50,000 people. The

region of Central Ostrobothnia consists of eight municipalities, two of which have city status. The other municipalities are relatively small, with the second largest having about 4,400 inhabitants. Geographically, however, the region is quite large, at just over 5,200 km². In practice, distances pose challenges for the operation of the LUMA Centre; for example, in distant municipalities, there are small schools to which it is challenging to spread activities.

Kokkola has 25 Finnish-speaking and 8 Swedish-speaking primary schools. There are three upper secondary schools for Finnish-speaking pupils and one for Swedish-speaking pupils. In addition, there are 24 primary schools and 4 upper secondary schools in the smaller municipalities of Central Ostrobothnia and a vocational school and University of Applied Sciences in Kokkola.

The Kokkola University Consortium Chydenius (www.chydenius.fi) is a higher education centre and functions as umbrella organization, coordinating the regional activities of various universities, with the objective of improving the visibility of these universities in the respective satellite areas. The Kokkola University Consortium Chydenius carries out teaching and research under the auspices of the universities of Jyväskylä, Oulu, and Vaasa. The Consortium's areas of specialization reflect those of its university partners: teacher education, ICT, social sciences, business, and chemistry. The University Consortium offers both master's degrees and doctoral level education. In addition, it engages in scientific research and arranges a wide range of adult education courses.

The economic structure of the Kokkola region is diverse. The basis of economic life is international large-scale industry, including the chemical industry and its associated industries. Traditional industries such as the metal industry and shipbuilding industries, also continue to play a significant role. The core of the chemical industry in the Kokkola region is Kokkola Industrial Park (KIP), which is the largest concentration of inorganic chemistry in the Nordic countries. There are about 70 companies operating in the KIP area.

The Kokkola region has invested heavily in the ICT sector and its development since the early 1990s. With the increase in education, recruitment, and the construction of new premises, the number of ICT employees has steadily increased. There are now just under 80 companies in the ICT sector, employing a total of almost 1,150 people. ICT companies in the Kokkola region cover all areas of ICT. New and emerging business areas in the region are wellness technology and cleantech.

B. Activities

The focus of the LUMA Centre of Central Ostrobothnia is on chemistry and information technology, due to the economic structure of the area.

The LUMA Centre strives to utilize a networking approach in its own operations. In practice, this means utilizing the resources of the national LUMA Finland network as far as possible. In addition, a strong network of STEM actors has been formed in the Central Ostrobothnia region to support

cooperation between schools, colleges, and universities; businesses (especially industrial networks such as Kokkola Industrial Park, the Federation of Finnish Technology Industries, and the Chemical Industry Federation of Finland); and other related actors such as the Innokas Network. The LUMA Centre of Central Ostrobothnia works actively with all network participants and seeks to promote their cooperation.

1) Support for schools: One of the Centre's main activities has been to support STEM teaching in schools through new teaching methods, materials, and environments; for example, the LUMA Centre has developed STEM-themed activities for various courses at all grade levels. The Centre has taken advantage of its national network to source teaching materials and experts for schools and has organized STEM-themed workshops at the Kokkola University Consortium Chydenius. The LUMA Centre has also acquired equipment for teaching programming thinking and basic robotics, which schools can use during their visits; equipment can also be borrowed. In addition, the LUMA Centre has coordinated and organized various STEM-related teacher training courses (e.g., on progressive inquiry and robotics). Many schools in the area have a teacher who acts as an STEM contact person, through whom information and communication relating to the STEM topic can be coordinated

2) Cooperation with teacher education: Efforts have been made to integrate STEM disciplines more effectively into the training of teacher students. As noted earlier, teacher attitudes and competencies play a major role in engaging children and young people in STEM subjects. The teacher education program at Kokkola University Consortium Chydenius qualifies students to teach at preschool level and in grades 1-6 of Finnish comprehensive schools. The teacher education program provides an excellent opportunity to influence the knowledge and attitudes of future teachers.

Teacher students are encouraged to complete Massive Open Online Courses (MOOC) on science and technology education and project-based learning created by the LUMA Finland network. STEM-related MOOC courses have been accredited as part of teacher students' own studies. Course content has been put into practice when students have supported classroom teachers in implementing STEM-themed projects in schools. In addition, attempts have been made to encourage teacher students to choose research and thesis topics relating to the teaching of STEM subjects. Students have also been recruited as instructors for STEM-related events for children.

In the future, the aim is to develop cooperation between the LUMA Centre of Central Ostrobothnia and teacher training schools, in order to deepen teacher students' skills in guiding research exercises by acting as instructors during the LUMA Centre's science class visits.

3) Science classroom in cooperation with the University of Applied Sciences: One special activity of the LUMA Centre of Central Ostrobothnia has been its cooperation with the University of Applied Sciences, which was facilitated by the fact that these higher education institutes are located almost adjacent to each other on the same campus. The main form

of cooperation has related to science classroom activities. The chemistry-related laboratory facilities of the LUMA Centre are located on the premises of the University of Applied Sciences and the supervision of chemistry assignments is mainly carried out by the staff of the University of Applied Sciences. Technology-related activities are in turn carried out on the premises of Kokkola University Consortium Chydenius, mainly by University staff.

The science classroom can be utilized in many ways, and activities that utilize it can be designed to suit the needs of particular schools. Groups of students and their teachers can come to the science classroom to conduct research. There are ready-made work packages to choose from in connection to various natural sciences and technologies. The students at upper secondary school can also do an Introduction to Working Life course by working in the science classroom. It is also possible to organize science club activities in the science classroom's laboratory facilities.

4) *Cooperation with the MyTech and Innokas Network:*

The LUMA Centre has acted as a regional coordinator for MyTech visits. The MyTech program (mytechohjelma.fi) is a nationwide program founded by the Federation of Finnish Technology Industries. The idea of the MyTech program is to strengthen phenomenon-based project learning and introduce students to technology companies. MyTech is aimed at upper comprehensive and upper secondary schools. The MyTech program includes a project day, during which students visit the high school and technology companies. The topics of the visits relate to applied chemistry and information technology. In practice, a visit to a high school has involved working in the above-mentioned science classroom.

As a new activity in 2019, cooperation with the so called Innokas Network (www.innokas.fi/en/) was started. The Innokas Network encourages schools to arrange activities that support STEM-related skills. The Innokas Network arranges training, consulting, and events in different parts of Finland. The purpose of the collaboration is to utilize the resources of both organizations to organize joint training events for teachers. An example of cooperation for schoolchildren is the implementation of a national robotics competition, with regional heats.

5) *Development of virtual solutions:* As stated earlier, Central Ostrobothnia is a geographically fragmented area; hence, one of the challenges is to reach schools outside the Kokkola area. A solution to this has been sought by developing a virtual environment to enable the sharing of good practices and proven learning materials. The virtual environment makes extensive use of video technologies and facilitates the easy production and distribution of video-based learning materials. The virtual environment also includes search functions for materials created for different school levels and different subjects.

6) *STEM-related project activities:* The LUMA Finland network is also an efficient project organization. One of the most significant projects launched by the network in recent years is the so-called LUMA2020 project (2020.luma.fi), in

which the Central Ostrobothnia LUMA Centre is also actively involved. The project was implemented in 2019–2020 and one of its key activities is to implement STEM-themed projects in schools and kindergartens. The ideas for STEM projects come primarily from the children themselves. LUMA2020 staff support teachers in implementing STEM-related projects, with the aim of utilizing the materials and best practices of LUMA Finland network's previous development programs and the expertise of the network. LUMA2020 covers 161 learning communities from all over Finland, including kindergartens, schools, and vocational institutes, as well as various leisure communities. The LUMA2020 project also develops the skills of teachers at different school levels through training and workshops. In addition, the project will offer free online courses and virtual clubs for all Finnish kindergartens and schools.

IV. CONCLUSION

The need for STEM experts is obvious; however, universities are not able to attract enough young people to the field. In Finland, efforts have been made to solve this challenge by launching the LUMA Centre Finland network, which consists of 13 centres connected with university campuses and aims to promote STEM activities in each area. Activities are aimed at all school levels, from pre-school to secondary school. The main idea of the network is that good practices, operating models, materials, and know-how are disseminated for the use of the entire network.

The main activities of the LUMA Centre of Central Ostrobothnia are supporting schools and teachers in STEM-related teaching and increasing teachers' STEM awareness and skills in conjunction with teacher training, science class activities, and cooperation with the University of Applied Sciences and other related actors. The LUMA Centre of Central Ostrobothnia is actively developing a virtual environment that enables the sharing of STEM-related good practices and proven learning materials. The Centre is also actively involved in a variety of STEM-related projects.

The benefits of STEM-related activities, such as an increase in the number of young people enthusiastic about STEM topics, will only be confirmed in the long term; however, indicators of the scale of activities, such as the numbers of children, young people, and their families reached by the activities, are impressive.

REFERENCES

- [1] M. Caprile, R. Palmén, P. Sanz, and G. Dente, "Encouraging stem studies for the labour market. study for the empl committee," 2015.
- [2] M. Sanders, "Stem, stem education, stemmania," *The Technology Teacher*, vol. 68, no. 4, pp. 20–26, 2009.
- [3] C. Sen, Z. S. Ay, and S. A. Kiray, "Stem skills in the 21st century education," *Research Highlights in STEM Education*, pp. 81–101, 2018.
- [4] A. Joyce and M. Dzoga, "Science, technology, engineering and mathematics education: Overcoming challenges in europe," *Brussels: European SchoolNet-Intel Educator Academy EMEA*, vol. 29, no. 12, p. 2015, 2011.
- [5] S. Marginson, R. Tytler, B. Freeman, and K. Roberts, "Stem: country comparisons: international comparisons of science, technology, engineering and mathematics (stem) education. final report." 2013.

- [6] T. Kennedy and M. Odell, "Engaging students in stem education." *Science Education International*, vol. 25, no. 3, pp. 246–258, 2014.
- [7] B. Priemer, K. Eilerts, A. Filler, N. Pinkwart, B. Rösken-Winter, R. Tiemann, and A. U. Zu Belzen, "A framework to foster problem-solving in stem and computing education," *Research in Science & Technological Education*, vol. 38, no. 1, pp. 105–130, 2020.
- [8] H. B. Gonzalez and J. J. Kuenzi, "Science, technology, engineering, and mathematics (stem) education: A primer." Congressional Research Service, Library of Congress Washington, DC, 2012.
- [9] I. Kudenko and À. Gras-Velázquez, "The future of european stem workforce: What secondary school pupils of europe think about stem industry and careers," in *Insights from Research in Science Teaching and Learning*. Springer, 2016, pp. 223–236.
- [10] E. Ostler, "21st century stem education: A tactical model for long-range success," *International Journal of Applied Science and Technology*, vol. 2, no. 1, pp. 28–33, 2012.
- [11] K. Husso and J. Alatalo, "Elinkeinopoliittinen tilannekuva, talvi 2020: Tem:n hallinnonalan näkemyksiä," 2020. [Online]. Available: <http://urn.fi/URN:ISBN:978-952-327-496-9>
- [12] N. DeJarnette, "America's children: Providing early exposure to stem (science, technology, engineering and math) initiatives," *Education*, vol. 133, no. 1, pp. 77–84, 2012.
- [13] P. M. Kurup, X. Li, G. Powell, and M. Brown, "Building future primary teachers' capacity in stem: based on a platform of beliefs, understandings and intentions," *International Journal of STEM Education*, vol. 6, no. 1, p. 10, 2019.
- [14] R. Prinsley and E. Johnston, "Transforming stem teaching in australian primary schools: Everybody's business," *Australian Government: Office of the Chief Scientist*, 2015.