



MINISTRY OF
EDUCATION AND CULTURE
FINLAND

Finnish National STEM Strategy and Action Plan

Experts in natural sciences, technology and mathematics
in support of society's welfare and growth

Publications of the Ministry of Education and Culture, Finland 2023:22

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Ministry of Education and Culture Helsinki 2023

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Abstract

This publication of the Ministry of Education and Culture presents the national LUMA Strategy 2030, prepared in 2021 and published online, as well as an action plan drafted in 2022 to implement it. The aim of the strategy and the action plan is to ensure that there is science and mathematics competence and understanding in society to promote wellbeing and growth that is socially, ecologically and economically sustainable.

The preparation of the action plan has involved a large number of actors and in line with the proposals and initiatives received from them. Measures are divided into three categories: 1) Measures for developing teaching and education, 2) measures for monitoring, surveys and general development, and 3) measures for promoting communications and interest. The measures were discussed more extensively than what is shown here. The action plan is not intended to limit the enthusiasm and initiative of the actors, as all measures to promote this issue are important.

While the action plan was prepared, it emerged that the education and its fields in technology should be emphasised more clearly than is obvious in the common national abbreviation LUMA (i.e. natural sciences and mathematics). For this reason, it was decided to use the abbreviation LUMATE in the action plan. It is particularly well suited when referring to the fields of working life, secondary education and higher education, and it corresponds more accurately to the international abbreviation STEM.

Keywords	mathematics, natural sciences, technology, technologies, science education, working life
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LUMA(TE)-strategia ja -toimenpidesuunnitelma Luonnontieteiden, matematiikan ja tekniikan osaajat yhteiskunnan hyvinvoinnin ja kasvun tukena

Opetus- ja kulttuuriministeriön julkaisuja 2023:22		Teema	Koulutus
Julkaisija	Opetus- ja kulttuuriministeriö		
Yhteisötekijä	Opetus- ja kulttuuriministeriö		
Kieli	englanti	Sivumäärä	25

Tiivistelmä

Tässä opetus- ja kulttuuriministeriön julkaisussa esitetään vuonna 2021 laadittu ja verkossa julkaistu kansallinen LUMA-strategia 2030 ja sille vuonna 2022 laadittu toimenpidesuunnitelma. Strategian ja toimenpidesuunnitelman tavoitteena on varmistaa, että yhteiskunnassa on LUMA-osaamista ja -ymmärrystä edistämään hyvinvointia sekä sosiaalisesti, ekologisesti ja taloudellisesti kestävä kasvua.

Toimenpidesuunnitelma on laadittu laajassa yhteistyössä eri toimijoiden kanssa ja niiltä saatujen aloitteiden ja ehdotusten pohjalta. Toimenpiteet on jaettu kolmeen ryhmään: 1) Opetuksen ja koulutuksen kehittämisen toimenpiteet, 2) Seurannan, selvitysten ja yleisen kehittämisen toimenpiteet ja 3) Viestinnän ja kiinnostavuuden edistämisen toimenpiteet. Toimenpiteitä tuotiin keskusteluun tässä esitettyä laajemmin, eikä toimenpidesuunnitelman ole tarkoitus rajata toimijoiden intoa ja aloitteellisuutta, vaan kaikki toimet asian edistämiseksi ovat tärkeitä.

Toimenpidesuunnitelman valmistelun yhteydessä nousi esiin tarve korostaa selvemmin LUMA-asiayhteydessä myös tekniikan koulutusta ja aloja. Toimenpidesuunnitelmassa päädyttiin sen vuoksi käyttämään LUMATE-lyhennettä, joka sopii erityisen hyvin työelämän aloihin, toisen asteen koulutusaloihin ja korkeakoulutuksen aloihin viitattaessa ja vastaa tarkemmin kansainvälistä STEM-lyhennettä.

Asiasanat matematiikka, luonnontieteet, teknologia, tekniikat, tiedekasvatus, työelämä

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Strategin och åtgärdsplanen för naturvetenskaper, matematik och teknik Experter inom naturvetenskap, matematik och teknik som stöd för välfärd och tillväxt i samhället

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Referat

I denna publikation av undervisnings- och kulturministeriet presenteras den nationella strategin för naturvetenskaper och matematik till 2030, som utarbetades och publicerades på webben 2021, samt den tillhörande åtgärdsplan som utarbetades 2022. Målet för strategin och åtgärdsplanen är att säkerställa att det i samhället finns kompetens inom naturvetenskaper och matematik för att främja välfärd samt en socialt, ekologiskt och ekonomiskt hållbar tillväxt.

Åtgärdsplanen har utarbetats i brett samarbete med olika aktörer och utifrån initiativ och förslag från dem. Åtgärderna är indelade i tre grupper: 1) utveckling av undervisningen och utbildningen, 2) uppföljning, utredningar och allmän utveckling samt 3) främjande av kommunikationen och intresset. Under beredningens gång diskuterades fler åtgärder än de som presenteras här, och det är inte meningen att åtgärdsplanen ska begränsa aktörernas initiativkraft, utan alla insatser som främjar målet är viktiga.

Vid beredningen av åtgärdsplanen observerades ett behov av att tydligare framhäva även tekniska utbildningar och branscher. I åtgärdsplanen används därför förkortningen LUMATE (naturvetenskaper, matematik och teknik) i stället för LUMA. Den passar särskilt bra vid hänvisning till branscher i arbetslivet samt utbildningsområden på andra stadiet och högskolenivå och motsvarar också bättre den internationella förkortningen STEM.

Nyckelord matematik, naturvetenskaper, teknologi, teknik, vetenskapsfostran, arbetsliv

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COMPETENCE IN NATURAL SCIENCES, MATHEMATICS AND TECHNOLOGY LAYS THE FOUNDATION FOR THE SUCCESS OF FINNISH SOCIETY

Learning and education in natural sciences and mathematics as well as in technology provide capabilities for understanding the world around us and for finding employment. The ability to monitor and structure knowledge about the surrounding world increases people's participation and allows them to live as part of communities and society. At the same time, wellbeing also increases. In addition, people who are feeling well and are skilled in natural sciences and technology are a very important resource for society and provide the ability to respond to workforce needs and solve the tricky problems of society. For these reasons, it is necessary to promote STEM teaching and competence development at different levels of education. At the same time, it is vital to anticipate and respond to the need for specialists in other areas of work.

This publication of the Ministry of Education and Culture presents the STEM strategy¹ prepared and published online in 2021 and the action plan prepared for it in 2022. Chapter 1 covers the STEM strategy, and Chapter 2 presents the measures of the STEM strategy.

The preparation of the STEM strategy began in spring 2021 as a measure of the National RDI roadmap. Related wishes had been expressed by different actors, and the Ministry of Education and Culture had held discussions with representatives of the education system, business life and other stakeholders. The national STEM strategy was published in autumn 2021 to ensure that society has STEM competence and understanding to promote wellbeing and socially, ecologically and economically sustainable growth. The strategy also strongly signalled that the implementation of its objectives must be a shared responsibility of all actors, and they must be implemented in cooperation between different actors and sectors.

The strategy action plan was prepared as a measure of the update of the National RDI roadmap in 2022. The preparation of the measures was carried out as extensively as possible in cooperation with different actors and stakeholders. A wide range of proposals for measures were received, involving a rich discussion at a webinar and a round of feedback on the draft action plan carried out on the otakantaa.fi online platform.

1 <https://okm.fi/luma-strategia>

In connection with the preparation of the action plan, the need to better emphasise technology education and its fields in the STEM context was highlighted. The broader Finnish abbreviation LUMATE was added to the terminology, which is particularly suitable when referring to the fields of employment, upper secondary education and higher education. Compared to the common Finnish abbreviation LUMA, the abbreviation LUMATE better corresponds to the English abbreviation STEM/STEAM. Many countries have strategies for STEM activities and sectors, usually also emphasising gender equality, equality and diversity. Naturally, these values are needed in the Finnish context as well.

In European education and industrial policy, STEM needs are widely identified. The European Commission promotes education that approaches, without limits, the connection of STEM and ICT teaching to art, human sciences and social sciences in a multidisciplinary way. At the same time, the aim is to demonstrate the connection between STEM competence and political, environmental, socio-economic and cultural objectives. Equal opportunities and enabling full talent potential according to each person's abilities play a key role.

Many thanks to the members of the STEM Strategy Working Group appointed by the Ministry in 2021 and the members of the Steering Group and the Working Committee of the STEM Action Plan appointed by the Ministry in 2022. Their focus on this work has resulted in a broadly effective and inclusive strategy and its measures. Many thanks also to the many stakeholders and individuals who have participated in national preparations at workshops and round tables or have given their comments in online surveys during the preparations.

Ministry of Education and Culture

1 STEM strategy 2030

1.1 Introduction

The STEM fields include natural sciences and mathematics as well as technology. A sufficient level of expertise in STEM and a sufficient number of experts are vital for the development of equality and wellbeing in society. A welfare society can only be preserved through ecologically, socially and economically sustainable choices and growth. STEM competence provides individuals and communities with good opportunities to understand and use research-based information diversely in everyday life and decision-making. It also promotes inclusion and active participation in the world around us. Global challenges are solved by applying multidisciplinary expertise and a culture of communal activity.

Multidisciplinary STEM activities in education and teaching promote enthusiasm for studying mathematics and natural sciences, for example through arts and design, and improve pupils' and students' self-direction, interaction and critical thinking skills. The starting point for multidisciplinary STEM activities is the STEAM² concept, which identifies the link between STEM and other sciences, such as arts and humanities.

Future-oriented STEM competence and STEM experts are also needed to support the development of working life. For example, in research activities, in business life and in the public sector, the ability to examine critical results, test one's own ideas, solve problems and assess risks are needed. Multidisciplinary STEM competence also promotes creativity and innovation capacity. Research and science are important not only as producers of new knowledge, but also as the basis for higher education and the entire education system.

The ability and interest brought about by science competence in the processing, acquisition, understanding and application of research-based information are part of citizens' basic skills. Science competence and communication about research-based information are a key part of STEM competence. Interest in science expertise builds the scientific capital of society and also the education and worldview of individuals while increasing participation.

2 STEAM is an acronym for *science, technology, engineering, arts and mathematics*.

Statistics and situation descriptions concerning the state of the STEM fields and competence and STEM measures are described in appendices to the STEM strategy online publication (in Finnish).³

Why a STEM strategy

The aim of the STEM strategy is to ensure that Finnish STEM competence promotes wellbeing and socially, ecologically and economically sustainable growth. STEM competence will only be strengthened in close cooperation between different actors and sectors. The measures must be prepared together, and the responsibilities must be allocated to different parties.

In national foresight work, natural sciences and mathematics are specified as key future competence needs in several sectors. They are basic competences, on which other competences are built, such as technology competence, innovation activities, the needs of sustainable development, circular economy and responsibility. Natural sciences and mathematics are also central competences in society and in acting as a citizen, regardless of the industry.

Technical and scientific competence is essential in technologies and digitalisation. STEM competence can be used to meet the challenges of future working life. These include preventing and slowing down climate change and pursuing carbon neutrality. It must be widely recognised that STEM activities must be based on research. This is the only way to ensure up-to-date learning and teaching as well as a future based on innovations.

The STEM strategy can promote equal opportunities. This way, the talent potential of the entire society can be used. At the same time, inequalities in learning are prevented and equal opportunities and sufficient capabilities for developing STEM competence are guaranteed regardless of age, social and cultural background, gender or language throughout Finland.

The preparation of the STEM strategy was included in the update of the National RDI roadmap in 2021. According to the RDI roadmap, science education deepens and increases the human resources available to the RDI environment, which can also be associated with increasing STEM competence. One of the key perspectives in the preparation of the STEM strategy is to secure the availability of STEM experts in different sectors and fields of working life.

³ The address of the online publication of the STEM strategy (2021) is <https://okm.fi/luma-strategia>.

STEM competence as the object of many perspectives

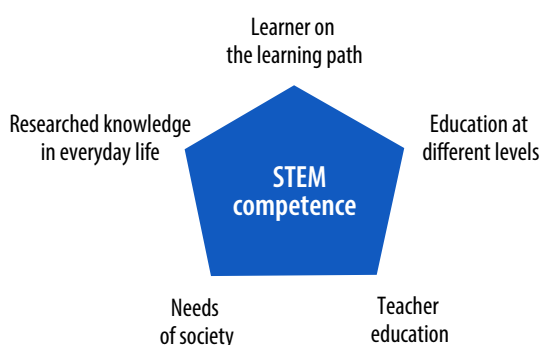
Recognising and acknowledging all aspects of STEM competence and combining them as a whole is necessary in strategic approaches. As presented in Figure 1, the perspectives include meeting the needs of society, such as the demand for skilled employees, the information needs of everyday life, the learner's path, including different transition phases and their threshold skills, and the needs for STEM learning and teaching related to education. Internationality crosses all perspectives as an element of cooperation and benchmarking.

The development of STEM competence is part of an individual learning path that begins at home, continues to early childhood education and care and to different levels of education, and develops into continuous learning. In addition to learning at different levels of education, it is complemented by different forms of science education and learning, such as study visits outside the school, hobbies, media and virtual learning environments. STEM skills are part of basic skills, similar to literacy, and they educate citizens to use research-based knowledge.

A key prerequisite for developing STEM competence in early childhood education and care and basic education, as well as upper secondary education, is high-quality teacher education based on research, including the development of teachers' competence during their careers. In addition to teaching staff, the guidance and support staff must have good capabilities to support diverse STEM activities and the development of STEM capabilities.

Vocational and higher education ensure the adequacy of STEM experts in working life in different sectors of society in terms of content, quality and quantity. There is a continuous need for education and training in working life. In many sectors, STEM competence is basic competence, based on which other vocational skills are built.

Figure 1. STEM competence as the object of different perspectives.



1.2 National challenges in STEM competence

Finland has a growing need for experts in different employer sectors. As economic growth accelerates, businesses and the industry signal that, depending on the sector, there is a huge shortage of experts at all levels. High-quality research requires high expertise. The needs of the public sector are not lower, either. Key factors in the operating environment, such as technological development, the transformation of working and business life, and the state of the environment and climate change, emphasise the importance of STEM competence in the workforce. On the other hand, competence needed to improve Finland's security of supply and increase crisis preparedness can be linked to the STEM sectors, as well as the labour needs of Finland's internal and external security.

Learning STEM subjects is considered important in society. However, studying and learning them are not taken as an individual's ability to participate in society and to make informed decisions. The number of applicants in different fields to higher education institutions also show that there is no widespread interest in the fields of science. At the same time, the number of applicants for teacher education has decreased steadily. In addition, in Finland, the share of those with higher education in the population remains below the OECD and EU average.⁴

Finnish young people's competence in mathematics and natural sciences has been declining since 2006, and at the same time their attitudes towards learning have deteriorated. Consequently the share of top experts in mathematics and natural sciences has decreased by half, while the share of those with poor skills in mathematics has doubled and in natural sciences has even tripled.⁵ The decrease in the competence of Finnish pupils completing comprehensive school in natural sciences and mathematics computationally amounts to the syllabus achieved during approximately one school year. The decline in competence has been the sharpest in Finland of the countries participating in the PISA survey. It would be important to address learning difficulties in mathematics as early as possible.

Gender remains strongly linked to the choice of field of education. Women, both in the OECD countries and in Finland, are clearly less likely than men to apply to the STEM fields. On the other hand, women's interest in STEM subjects is reflected in the increase in the number of enrolments over the past few years, but a corresponding trend is not seen in

4 OECD Education at a Glance 2020

5 OECD PISA study 2018

postgraduate studies. In the technical and ICT sectors in particular, women are clearly a minority. The share of women among new students in the higher education STEM sector increased by less than one percentage point in Finland between 2013 and 2019.

The challenge is the small share of qualified teachers in early childhood education and care (ECEC) staff, although mathematical thinking should be emphasised more strongly in ECEC. Early skills are linked to learning mathematics, and early mathematical understanding also creates positive meanings for other learning and future studies. The mastery of pedagogical content of mathematical subjects should be strengthened in the education of ECEC teachers. STEM education requires didactic competence. In degree education for personnel groups other than teachers in early childhood education and care, this is not at the centre of education.

Ideas of deteriorating working conditions in teaching work do not encourage young people to seek employment in the teaching sector.⁶ It is challenging to ensure the adequacy of qualified teachers of STEM subjects that continuously develop their competence. The attractiveness and quality of teacher education in STEM subjects must be improved. School teaching, guidance and support staff must be able to tell young people about the STEM field and different career options. Teachers' self-efficacy must be supported in order to provide learners with high-quality teaching of STEM subjects from early childhood education to upper secondary education.

The motivation and attitudes of Finnish young people, especially girls, partly prevent students talented in mathematics and natural sciences from being interested in mathematical and natural science professions. The low baseline competence of young people seeking to study mathematics and natural sciences may make it difficult to start further studies and successfully complete them. Motivation and competence feed each other. It should be possible to start this positive development as early as possible and to maintain strengthening measures throughout the school and study years. Positive learning development and role models are important for the pupils themselves and for society.

Science communications should reach diverse target groups. Discussion and communication should be versatile, cross-cutting and accessible. Communication should go seamlessly between different levels of teaching and between learning communities and business life.

6 Heikkinen, L. T. et al. (2020). Opettajankoulutuksen vetovoima. Loppuraportti. Ministry of Education and Culture publications 2020:26.

1.3 Vision for 2030

In 2030, individuals can supportedly improve their STEM skills as continuous learning throughout their life, and there will be enough STEM experts in Finnish society. Citizens have the information literacy required for participation in society. These promote inclusion, wellbeing and sustainable development.

1.4 Strategy objectives

Smooth everyday life, functioning society. Finns' everyday lives will run smoothly, the welfare society can be maintained and Finland will succeed in international competition when we are able to raise the level of competence and improve the availability of labour. Most of the new jobs will require competence level of higher education. Occupations requiring STEM competence and tasks requiring STEM understanding are emphasised in those sectors that create new jobs. Complex phenomena that have a wide impact on everyone's daily life, such as climate change and health security, are easier to understand when information floods can be filtered based on information and acted on. Higher education actors and the education administration sector, in particular, are responsible for raising the level of competence and putting a quantitative focus on the necessary fields.

STEM competence passes the functions of society. Measures following the strategy should include raising the STEM competence level in teaching and working life, increasing the labour supply of STEM professionals and STEM experts, responding to employers' STEM competence needs, and improving individuals' and communities' STEM capabilities. The national objectives of continuous learning and the objectives of vocational education and training are taken into account. The responsibility for the objective is divided between education actors and different employer sectors.

Early childhood education and care and teaching at different levels are of high quality. Developing STEM education and teaching requires investing in teaching methods, such as more learner-specific or phenomenon- and theme-based models, and teachers' good pedagogical skills and their own STEM competence. Teacher education must be based on research. Education must increase and promote equality so that the STEM competence potential of the society as a whole and its application can be used. High-quality development of teachers' skills and competence during their careers must be enabled,

and obstacles to participation in continuing education must be removed. The parties responsible for the target include teacher educators, education providers and the parties responsible for teachers' continuing professional development.

STEM studies are interesting. Action must be taken to promote studies in the STEM fields and selection of potential STEM careers. The voice of children and youth in the planning and implementation of teaching and its activities enables the creation of new learner-centred solutions and operating models. Many opportunities for career choice and the importance of STEM competence in different careers should be actively communicated. Resources should be directed in the required direction using foresight data. The attractiveness of teacher education in STEM subjects must be taken into account, and teacher education must be scaled according to needs. Attention will be paid to continuing education for teachers. The responsible parties are employers, trainers and the administrative branch of education.

Communication about STEM competence and its opportunities will increase. Other strategic objectives must be supported by means of communication. Dismantling identified challenges, such as bad images and public awareness of contemporary science and innovations or their opportunities, or, for example, the need to maintain crisis preparedness, can be approached through communication. The tools available include participatory science education, campaigns and media visibility. All those working in STEM are responsible for communication and interaction with different target groups. Communication highlights themes that cross-cut the different objectives of the strategy, such as the promotion of equality, non-discrimination, climate change and other global challenges, and the international operating environment.

2 STEM action plan

At the beginning of preparing the action plan for the STEM strategy, it was noted that the Ministry of Education and Culture is willing and can create preconditions and incentives for developing STEM teaching and developing and increasing STEM education and competence⁷ in society. In addition, the Ministry of Education and Culture is linked to the preparation of working life policies and numerous actors throughout society. However, Ministries can steer actors only to a limited extent in different sectors and sometimes even in their own administrative branch, as is the case with, for example, higher education institutions that are autonomous through legislation. For this reason, the approach and implementation method were chosen in the preparation of the action plan, in which different actors and parties themselves assumed responsibility for highlighting the measures and committed to their implementation.

The action plan has been drawn up on the basis of initiatives and proposals received from different actors. Not all initiatives could be summarised into concrete measures with a clear responsible party, or a consensus could not be reached on them. During the preparation process, it was also noted that new perspectives and interested actors continued to emerge to promote STEM competence. Therefore, the measures presented in this publication must not limit the enthusiasm and initiative of the actors, but all new measures to promote the matter are important. The list of measures is not a static presentation, but requires clarification and review after a suitable time.

The five objectives of the strategy describe the perspectives related to STEM activities in society. It is important to identify them and, if necessary, present them as a whole. However, the presentation of the STEM measures in accordance with the strategy's target grouping did not prove effective. In the preparation process, it was decided to divide

7 The STEM strategy used the Finnish abbreviation LUMA, referring to science and mathematics along with technology. In connection with the preparation of the action plan, the need to better emphasise technology training and its fields in the STEM context was highlighted. The Finnish abbreviation LUMATE (natural sciences, mathematics, technology) is also compatible with the international abbreviation STEM. The abbreviation LUMATE, which emphasises technology more broadly, is particularly suitable when referring to the fields of employment, upper secondary education and higher education.

the measures into three groups: 1) Measures for developing teaching and education, 2) Measures for monitoring, surveys and general development, and 3) Measures for promoting communication and interest.

2.1 Measures for developing teaching and education

No	Action	Party responsible	Time span
1	<p>Strengthen positive attitudes towards mathematics in early childhood education and care through play and an exploratory approach as well as a number- and form-conscious environment.</p> <p>Strengthen the pedagogical competence of early childhood education teachers through continuous learning methods related to play and everyday situations in mathematics and natural sciences and science education.</p>	Ministry of Education and Culture, Finnish National Agency for Education, ECEC providers, publishers of learning materials, science centres, higher education institutions	2023–2030
2	<p>Promote and support learning and teaching in mathematical and scientific subjects and technical fields at all levels of education, with equal encouragement for all genders. Support the expansion of the education developer model, especially in basic education. Reserve resources for the activities of education developers. Use existing networks in the implementation of the education developer model for developing mathematics and natural sciences subjects.</p> <p>The means is to strengthen the mathematical and science competence of class teachers, the pedagogical competence of subject teachers in related fields, the mathematical and science competence of vocational teachers, and the mathematical competence of special needs teachers through various means of continuous learning, such as continuing education and sharing of competence in schools, educational institutions and different networks</p>	Ministry of Education and Culture, Finnish National Agency for Education, providers of ECEC, primary education and upper secondary education, higher education institutions	2023–2030
3	Deploy new research knowledge to all levels of education by producing support material and organising training on teaching in mathematics and science.	Finnish National Agency for Education, education and training providers	2023–2030
4	In natural sciences and mathematics, raise the level of competence to the level of the early 2000s by increasing the resources for teaching and support, ensuring the mastery of at least basic skills for everyone.	Ministry of Education and Culture, Finnish National Agency for Education	2023–2030

No	Action	Party responsible	Time span
5	Increase the provision of advanced studies in mathematics and natural sciences for all upper secondary school students. Offer support to those starting upper secondary school and, if necessary, an opportunity to supplement their mathematical and natural sciences competence to the level required in upper secondary school studies with adaptive study modules.	Upper secondary schools in the special STEM training assignment and upper secondary schools in the national STEM development assignment	2023–2030
6	Promote cooperation between upper secondary schools and higher education institutions and create incentives for studying mathematics, natural science and technical subjects while promoting equality and non-discrimination.	Ministry of Education and Culture, Finnish National Agency for Education, upper secondary education providers, higher education institutions	2023–2030
7	Encourage providers of vocational education to continue teaching mathematics and science subjects as part of professional content. In vocational education and training, maintain the sectoral nature of teaching and the link with working life.	Finnish National Agency for Education, providers of vocational education	2023–2030
8	In order to develop the mathematical, natural sciences and technology orientation of vocational education and training, increase cooperation between vocational institutions, universities of applied sciences and the regions' work and business life. Strengthen the workplace orientation of vocational education and training through guidance counselling and through the development of apprenticeship periods. Review the possibilities of developing feedback on working life to support the assessment in STEM subjects in vocational education and training.	Providers of vocational education, universities of applied sciences, municipalities, business life, Ministry of Education and Culture	2023–2030
9	Based on foresight work, emphasise mathematics, natural sciences and technology in decision-making concerning the volume of education: in deciding on the volumes of vocational education and training, increasing the number of students in higher education to achieve the national target of 50% of young adults with higher education, and increasing the number of new foreign students in higher education institutions towards 15,000 students.	Higher education institutions, Ministry of Education and Culture, providers of vocational education	2023–2030
10	When developing student admissions to universities and universities of applied sciences, ensure in relevant fields that the choices encourage students to study subjects in mathematics and natural sciences.	Higher education institutions	2023–2030

No	Action	Party responsible	Time span
11	Develop teacher education in the fields of mathematics, natural sciences and technology and the competence of teacher educators based on needs and research-based.	Higher education institutions, LUMA Centre Finland, Teacher Education Forum / national forum, Ministry of Education and Culture, Finnish National Agency for Education	2023–2030
12	Set up a working group to examine the functionality and development needs of teacher education and, in particular, class teacher education structures in order to ensure teachers' sufficient competence in mathematics and science, as well as ways to better respond to teacher needs in the fields of mathematics, science and technology and to strengthen the attractiveness of teacher education.	Ministry of Education and Culture	2023–2024
13	In teacher education and the provision of continuous learning for teachers, take into account the competence needs related to teachers' sustainable development and mathematical and natural sciences competence. Increase opportunities for international cooperation between teachers in mathematics and science.	Higher education institutions, LUMA Centre Finland, Teacher Education Forum / national forum, Ministry of Education and Culture, Finnish National Agency for Education, providers of continuous learning	2023–2030
14	When necessary, assess and take into account the need for a group focusing on mathematics, natural sciences and technology in vocational teacher education and training, and develop the selection processes for teacher education in the fields of mathematics, science and technology.	Universities of Applied Sciences (vocational teacher education)	2023–2030
15	Invest in pedagogical development in the fields of mathematics and science and technology in higher education and intensify cooperation in their teaching. Intensify cooperation through co-teaching and within faculties / units, between different higher education institutions and internationally, for example through joint projects and cross-providing teaching.	Higher education institutions	2023–2030

2.2 Measures for monitoring, surveys and general development

No	Action	Party responsible	Time span
16	Examine whether early childhood education and care, pre-primary education and grades 1–2 provide an adequate basis for developing competence in mathematics and natural sciences for a lifelong need. Determine the state of support for the teaching of science subjects and in mathematics in basic education. Strengthen the ensuring of the preconditions for competence with additional resources.	Ministry of Education and Culture, Finnish National Agency for Education.	2024
17	Prevent the unfavourable impact of the learner's background on mathematics and natural sciences competence and educational pathway by organising free, high-quality and equal study visits to higher education institutions as part of school education and early childhood education and care in accordance with the curriculum. Support the seamless transitions of learners and functional connections also by preparatory education for degree education (TUVA).	LUMA Centre Finland, higher education institutions, Finnish National Agency for Education	2023–2030
18	In the implementation of the General upper secondary school quality strategy, education providers take into account the attractiveness of mathematics and science subjects, the planning of joint studies, opportunities for further studies and the mitigation of segregation impacts.	Finnish National Agency for Education, education providers	2023–2030
19	Produce diverse research data on early childhood education and care, basic education and upper secondary education, and use it in the development of new practices. Develop doctoral programmes in the fields of mathematics and science and increase the number of doctoral researcher positions.	LUMA Centre Finland, universities	2023–2030
20	Stakeholders invest as actors in the development of mathematical and natural science competence, teaching, learning environments and informal learning in accordance with their own objectives, which is emphasised especially in early childhood education and care and basic education as well as in increasing cooperation between different stakeholders.	Pedagogical teacher organisations, science centres, museums and other stakeholders	2023–2030

No	Action	Party responsible	Time span
21	Survey the state of teaching in technology and programming and algorithmic thinking in basic education, and produce proposals for strengthening teaching on this basis.	Finnish National Agency for Education, (FINEEC)	2023–2024
22	Support LUMA Centre Finland and allocate resources to the network's coordination and operations.	Ministry of Education and Culture, higher education institutions	2023–2030
23	LUMA Centre Finland's advisory board monitors the implementation of the measures of the STEM strategy and reports on it annually to the Ministry of Education and Culture.	LUMA Centre Finland and stakeholders	2023–2030

2.3 Measures for promoting communication and interest

No	Action	Party responsible	Time span
24	Support the promotion of science education and science competence at, for example, science centres and the media, making use of networks. Increase communality and cooperation between different levels of education, businesses, organisations, museums, science centres and networks, for example through joint projects.	Ministry of Education and Culture, science centres, organisations, museums and other stakeholders and media actors	2023–2030
25	Provide opportunities for recreational science and technology hobbies for children and young people. Pay attention to the equal implementation of opportunities, for example with regard to different genders and people with an immigrant background.	Municipalities, science centres, higher education institutions, museums, libraries and other hobby organisers, LUMA Centre Finland	2023–2030
26	Develop the working life and guidance skills of subject teachers in mathematics and natural sciences as well as the competence of guidance and career counsellors through continuous learning. Take into account the changing competence needs in the training and emphasise the need for equal guidance.	Finnish National Agency for Education, providers of continuous learning, higher education institutions, representatives of business/working life and organisations	2023–2030

No	Action	Party responsible	Time span
27	Use science competition activities to offer learners of different ages and teachers opportunities to present their competence. Participation supports multidisciplinary and innovative mathematical competence and competence in natural sciences as well as interest, whereby it is important to allocate sufficient resources.	LUMA Centre Finland, higher education institutions, associations, foundations, organisations	2023–2030
28	Strengthen together, by using communication and events, the interest and understanding of children and young people and different genders and underrepresented groups in the significance of mathematics and natural science subjects in their competence, further studies and working life and in solving major societal challenges. Maintain supply and discussion in the media and social media 1) on subjects and learning in the field of mathematics and science and technology and 2) on education in mathematics, natural sciences, and technology.	Representatives of working life and other STEM stakeholders	2023–2030
29	Increase parents' awareness of the development of early mathematical skills and support for development. Provide parents with additional information through the media and, for example, maternity and child health clinics, on how the development of mathematics and natural sciences competence can be supported at home, in nature and in the surrounding environment.	Pedagogical teacher organisations and other actors in the field	2023–2030
30	Improve the opportunities of children and young people to influence and support their active citizenship related to mathematics and natural sciences and technical themes.	Youth councils and youth organisations; schools and educational institutions	2023–2030
31	Increase the attractiveness of the profession of teachers in mathematics and natural sciences and technology through joint campaigns. The aim of the cooperation is to present the teacher's profession and to encourage young people and traders to apply to the field.	LUMA Centre Finland, pedagogical teacher organisations, higher education institutions and other actors in the field	2024–2025

Appendix 1. Working group on the preparation of the STEM Strategy

On 15 June 2021, the Ministry of Education and Culture appointed a working group to prepare the STEM strategy. The working group's term was 15 June 2021–31 October 2021, and its task was to prepare a proposal for a national STEM strategy, to examine the different perspectives of STEM activities and their impact, and to consult stakeholders in the preparation of the strategy.

Director Erja Heikkinen, Ministry of Education and Culture was invited to chair the working group. Members of the working group were Senior Ministerial Adviser Paavo-Petri Ahonen, Ministry of Education and Culture; Senior Ministerial Adviser Tommi Karjalainen, Ministry of Education and Culture; Senior Engineer Inga Sihvo, Finnish National Agency for Education; Senior Ministerial Adviser Aki Tornberg, Ministry of Education and Culture; and Senior Ministerial Adviser Marjo Vesalainen, Ministry of Education and Culture. The specialist secretary of the working group was Project Planner Oona Kiviluoto, LUMA Centre Finland.

The LUMA strategy prepared by the working group was published online in December 2021.

Appendix 2. Steering group of the action plan for the STEM strategy

On 5 May 2022, the Ministry of Education and Culture appointed a steering group for the preparation of the action plan for the STEM strategy. The term of the steering group was 5 May 2022–31 December 2022, and its task was to steer the preparation of the action plan for the STEM strategy, to produce ideas for the actions of different sectors and actors in society, and to examine the perspectives of society as a whole in its guidance.

Senior Ministerial Adviser Paavo-Petri Ahonen, Ministry of Education and Culture, was invited to chair the steering group. As members of the steering group, the following parties were invited: specialist Touko Apajalahti, Technology Finland; Specialist Maiju Korhonen, Finnish Energy; Senior Specialist Lauri Kurvonen, Trade Union of Education OAJ; Professor Jan Lundell, University of Jyväskylä / LUMA Centre Finland; Director of Social Relations Juhani Nokela, TEK (Trade union for academic engineers and architects in Finland); Managing Director Heini Oikkonen-Kerman, Museum of Technology / Finnish Science Centres; Project Manager Päivi Ojala, Suomen Yrittäjät; Head of Education and Competence Reetta Pilhjerta, Finnish Forest Industries Federation; Education and Economic Policy Expert Aaro Riitakorpi, the Union of Professionals in Natural, Environmental and Forestry Sciences Loimu; Chief Specialist Anni Siltanen, Chemical Industry Federation of Finland; Senior Specialist Nadia Tamminen, Pharma Industry Finland; Chief Specialist Emmi Venäläinen, Akava Confederation of Unions for Professional and Managerial Staff in Finland; and Senior Ministerial Adviser Marjo Vesalainen, Ministry of Education and Culture.

The steering group's work was supported and the text of the action plan was prepared by a separate working committee appointed by the Ministry of Education and Culture.

Appendix 3. Working committee of the action plan for the STEM strategy

On 9 May 2022, the Ministry of Education and Culture appointed a working committee to prepare the action plan for the STEM strategy. The term of the working committee was 9 May 2022–31 December 2022, and its task was, under the guidance of the steering group, to prepare the action plan for the STEM strategy and to take into account the perspectives of different sectors and levels of education in society.

Senior Ministerial Adviser Marjo Vesalainen, Ministry of Education and Culture, was invited to chair the working committee. As members of the steering group, the following parties were invited: Senior Ministerial Adviser Tommi Karjalainen, Ministry of Education and Culture; Project Planner Oona Kiviluoto, University of Helsinki / LUMA Centre Finland; Counsellor of Education Leo Pahkin, Finnish National Agency for Education; and Senior Ministerial Adviser Aki Tornberg, Ministry of Education and Culture.

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