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STEM Project Handbook:
The STEM best practices in the EU and Partner countries

Sweden, Finland, Ireland, Türkiye, Kazakhstan

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Chapter 1: STEM best practices in Sweden

Janerik Lundquist, Linköping University, Sweden

STEM-Related National Policies in Sweden

The curriculum for mainstream, preschool and school age (revised 2018)[1] has pages dedicated to Technology: Curriculum for mainstream, preschool, and school education[2]. Instead of Sweden's national secondary and tertiary education policy, we can turn to passages relating to Sweden from Do Well Science - Manuals to Innovative Pedagogy in STEM Content.

There is no specific policy in Sweden for the development of STEM education, but the diploma goals for a science program (gymnasium, high school) can be seen as a STEM policy: The science program is a program to prepare for higher education. With a diploma of completion of the program, students must have the knowledge necessary to obtain higher education, primarily in the field of natural sciences, mathematics and technology, as well as in other fields.

STEM in Swedish universities

KTH - Royal Institute of Technology (Swedish: Kungliga Tekniska högskolan), the Department of Learning in Engineering Sciences[3]

Learning in STEM. Learning in STEM (Science, Technology, Engineering and Mathematics) is one of four units at the Department of Learning, belonging to the School of Industrial Engineering and Management (ITM) at KTH. The unit consists of three research groups: Engineering Education in Society, Higher Education Organizational Studies (HEOS) and Learning in Technology and Science Education (TN-didactics). In addition to our research and development, the unit has KTH-overall assignments and competence in engineering education.

Courses at Learning in STEM[4]

Learning in STEM (Science, Technology, Engineering and Mathematics) offers courses for teachers from P-12 education and higher education. The unit also offers courses for doctoral students.

[1] https://www.skolverket.se/getFile?file=3984
[2] https://www.skolverket.se/andra-sprak-other-languages/english-engelska
[3] https://www.kth.se/en/larande/stem/larande-i-stem-1.804298
[4] https://www.kth.se/en/larande/stem/kurser-1.826546

Courses in teaching and learning in higher education for KTH employees and doctoral students, Postgraduate and Doctoral courses at learning.

STEM degrees [88] are Science, Technology, Engineering, and Mathematics programs. They all require using research and reasoning to solve problems. And, they could lead to diverse career paths in growing fields. Within each category, you'll find many kinds of STEM graduate degrees. For example, engineering students could study civil, electrical, or computer engineering. Science students could study everything from biology to veterinary and animal sciences. You could pursue goals that range from building bridges to keeping IT systems safe. No matter what path you pursue, STEM careers are key to a brighter future.

Jönköping University became a member of the International Centre for STEM education 2018-12-04[5]. The School of Education and Communication at Jönköping University has become an elected member of the International Centre for STEM Education (ICSE), a consortium of 14 European universities that are collaborating to carry out research in STEM education.

In summer of 2018, the School of Education at Jönköping University became an elected member of ICSE. The ultimate aim of ICSE is to help improve STEM education across Europe through practice-related research and its transfer into practice. STEM is a term used to group together the academic disciplines of science, technology, engineering and mathematics.

Through membership in this prestigious consortium, the university has access to collaborations with some of the most successful international research institutes in STEM education research.

National stakeholders involved in STEM

- Ministry of Education and Research
http://www.government.se/government-of-sweden/ministry-of-education-and-research/

- Swedish National Agency for Education
http://www.skolverket.se/

- Teknikforetagen. The Association of Swedish Engineering Industries
http://www.teknikforetagen.se/
National policies and programmes

- NTA. Science and Technology for All
www.ntaskolutveckling.se/In-English

[5] https://ju.se/en/about-us/press/news/news-archive/2018-12-04-ju-becomes-member-of-international-centre-for-stem-education.html.

- Country Report Sweden 2015 Including an In-Depth Review on the prevention and correction of macroeconomic imbalances. Broader paths from school to work through vocational education and apprenticeships
http://ec.europa.eu/europe2020/pdf/csr2015/cr2015_sweden_en.pdf

- EURYDICE. National Reforms in School Education
https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Sweden:National_Reforms_in_S chool_Education

Initiatives, projects, good practices of national relevance, involving companies

- The Problem Solver

http://problemlosarna.nu

- Ingenjorsvagen

http://www.ingenjorsvagen.se

Chapter 2: STEM best practices in Finland

Oona Kiviluoto, University of Helsinki, Finland

Continuous professional development is part of STEM teacher training

LUMA Centre Finland is a network of Finnish universities that organise teacher training. LUMA is an abbreviation standing for natural sciences (LUonnontieteet) and mathematics (MAtematiikka), internationally it stands for STEM. 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 teaching/learning materials that make these subjects more interesting and motivating for young people.

Another main goal is to support the lifelong learning of teachers from early childhood education to the university level and to strengthen the development of research-based teaching. LUMA Centre Finland is an umbrella organisation that consists of 13 regional LUMA Centres. 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 reach all teachers with continuous professional development in STEM (in short CPD). Regional LUMA centres function as the link between university research and local education practices by 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 organisation 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 in Finland contributes to the needs of employers and employees in scientific and technological fields.

Starting in the year 2017, LUMA Centre Finland has received a 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.

Collaboration with schools and teachers

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

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

Another way for starting collaboration is to introduce it into STEM teacher education; as the practice has shown, this method is useful to such a degree that it should be mentioned. In practice, pre-service teachers become familiar with LUMA activities and personnel as a part of their studies, and they get an overview of the possible support LUMA Centre Finland can offer. On one hand, this encourages them to utilise STEM equipment, laboratories, and materials after graduation as they have seen the value of this already during their studies. On the other hand, it makes communication easier when people already know each other, which can be a surprisingly important factor for fruitful cooperation to get started in schools.

LUMA laboratories, located in Finnish universities, and their equipment are one essential continuous collaboration activity between LUMA Centres and schools. There are different models for this collaboration: bringing classes to LUMA laboratories for guided visits, or borrowing equipment for schools, with or without instructions. All these benefit schools as they can have access to equipment that typically schools cannot afford, and visits to new sorts of learning environments might motivate and intrigue learners toward STEM.

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

Role of the research in STEM education

In Finland, research is integrated into all science education provided by the LUMA Centre Finland. All science education activities are designed to produce new pedagogical knowledge and solutions. The quality assurance of the activities is also carried out through research. The research model widely applied by the LUMA Centre Finland is collaborative and inclusive design-based research that engages both pre- and in-service teachers. STEM activities are developed from the basis of research literature (theoretical problem analysis) and constantly evaluated and re-designed through research phases (empirical problem analysis). The design process is iterative and cyclic, which allows constant evaluation of the quality of each STEM activity.

In practice, for example, in-service teachers participate in STEM workshops that are aimed at both pre-service and in-service teachers. In these workshops, STEM teacher students' network with in-service teachers. After the workshops, both in-service and pre-service teachers implement the new methods and experiment in their classrooms or pedagogical training. New knowledge is converted into small-scale research projects and the impact of the training is recorded by the teachers themselves. The results are then considered together with the other participating teachers and students, from the perspective of previous research findings and theory. This way, teachers and teacher students have a chance to get peer support and to reflect on the new activity. Testing new methods also teaches students about the nature of science and help them to see teachers work as part of the scientific community. This model provides the LUMA Centre Finland with important and detailed data on the effects that the STEM activity has had on the teachers, their students and teacher students.

Teacher education in collaboration with industry

During the last few decades, it has been commonly understood that students´ interest in STEM subjects has decreased. This has become problematic, for example, for industries that need employees with sufficient scientific knowledge and skills. The connections between STEM subjects and knowledge of industries, with different professions and products, can increase students´ interests, positive attitudes and achievement. Therefore, it is essential for teachers to introduce industry-based examples and experiences to their teaching, at the early stages of education.

There are many ways to introduce industry-based examples to teaching. For example, field trips are beneficial and motivating for students although they are mostly done within museums, botanical gardens or scientific centres and less to visit industries. Industry-based collaboration can be beneficial for the whole community around the school. It can also be motivating for students, teachers and parents. In order to promote interactions between the world of industry and the world of education, it is crucial to develop the abilities of teachers to create and manage such interactions, either pre-service or within-service.

In Finland, generally, teachers with a STEM major subject at the Master´s level will be qualified to teach at all school levels: mandatory comprehensive school (grades 1-9),

voluntary vocational or upper secondary school (grades 10-12) and at the higher level, except for university. The working-life studies during teacher education are voluntary. For example, at the University of Helsinki, Science and Mathematics in Society (5 ECTS) is included in pre-service teachers' voluntary working life studies. In the course, pre-service teachers practise collaboration with industry members and the local school and make teaching material. The focus of the course is in the local companies and institutes in order to save schools´ resources like time and money.

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

There is a moderate amount of school-industry cooperation during basic education. Students seldom make visits to the companies although they are the most preferred teaching methods when asked by students. School-industry cooperation and visits are also preferred by teachers, but they do not have enough time and other resources to implement them in teaching. The cooperation can be planned and implemented by the teacher or with the cooperation of the university, for example. The recommendation is to teach and practice collaboration with industry during the STEM teacher training. This way future teachers have the tools to organise collaboration individually when entering school work.

Chapter 3: STEM best practices in Ireland

Keelin Leahy, University of Limerick, Ireland

To represent best practices in STEM the government in Ireland has given special attention to improving the quality of education in science, technology, engineering and mathematics (STEM). This includes high-quality training of graduates of STEM disciplines to ensure the development of the knowledge economy. The STEM Education Policy Statement and Implementation Plan for Schools represents an understanding of STEM education for the Irish context, and the embedding of this understanding across the education system will help transform the STEM education experience of learners from early years through to post-primary.

In November 2016 a Report on Science, Technology, Engineering and Mathematics (STEM) Education was published. While this report has focused almost exclusively on the STEM disciplines and STEM Education in general, it is now well established that the intersection of these areas with the Arts (visual and performing) and Design offers great potential in terms of both cultural advancement and economic development opportunities. With this in mind, it is important that any future strategy for STEM in Ireland takes account of the STE(A)M hybrid, where A represents the Arts and Design (including design thinking). It is proposed, therefore, that the Royal Irish Academy play a formal role in advancing the thinking on this topic in the Irish context with a view to influencing future policy decisions regarding STEM Education.

The STEM Education Report was followed by development of the STEM Education Policy Statement and Implementation Plan. Implementation of this approach will take place over several phases from 2017 till 2026. Recently Implementation Phase 2 completed (2020-2022) which focused on deepening capacity building and supporting a coherent STEM environment. At present Implementation Phase 3 (2023-2026) is commencing which will focus on realising the vision of providing the highest quality STEM education experience for learners. Actions in phase 3 will be informed by reviews of Phases 1 and 2, ongoing research and the changing educational and societal environment.

STEM Education Policy Statement (2017-2026) focusses on the many strengths in STEM education while providing a roadmap to address the areas for development. In developing this Policy Statement, three key principles have been identified that will underpin all STEM education initiatives: STEM is about igniting learners' curiosity so they participate in solving real world problems and make informed career choices; STEM is interdisciplinary, enabling learners to build and apply knowledge, deepen their understanding and develop creative and critical thinking skills within authentic contexts; STEM education embodies creativity, art and design. The actions outlined for STEM education will build on a range of reforms and activities already underway

such as curriculum reform and innovative teaching, learning and assessment. They are also informed by the STEM Education in the Irish School System Report, research and extensive consultation with stakeholders. Other influencing factors include parents' perceptions, expectations and the evolving STEM education ecosystem.

In parallel with government policy and implementation plans, there are many concepts and projects supporting best practice for STEM education in Ireland. These include:

- EPI-STEM The National Centre for Excellence in Mathematics and Science Teaching and Learning, University of Limerick. The Centre aims to improve STEM education through research into effective teaching, learning and professional development. The mission of EPI-STEM is to conduct an integrated program of research, teaching, and engagement that addresses national and international challenges in STEM education.
- Numeracy Across the Curriculum Project (2019). This project seeks to develop teachers' understanding of numeracy, while also guiding teachers on how to recognize and embed numeracy opportunities within their subject area.
- Common European Numeracy Framework, a Common European Numeracy Framework (CENF) (2019-2021) established and a set of professional development modules for adult numeracy educators will be developed.
- A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences: How to Measure It, How to Reduce It? The relevance of the study is due to the fact that although the description mathematical and natural sciences have long and honourable traditions of participation by highly creative women contributors, however, the percentages of women scientists remain shockingly low and there is a significant gender gap at all levels between women and men.
- Pre-service teachers' understanding of the concept of numeracy as a cross curricular subject in post-primary schools in Ireland (2016-2020). This study served the purpose of assessing pre-service teachers' understanding of the concept of numeracy as a cross curricular subject and to identify the knowledge required by pre-service teachers to integrate numeracy into their lessons.
- Primary and Post Primary teachers' insights into their teaching of algebra (2018-2020) This research focused on teachers' insights into their teaching of algebra, particularly during the transition from primary to post-primary school.
- What's the Point? Teachers Perspectives on the Incentive of Bonus Points for Studying Higher Level Mathematics (2018) In Ireland, a Bonus Points Initiative (BPI) was introduced in 2012 for mathematics. The main aim of this study is to investigate the benefits and challenges associated with the BPI from the perspective of mathematics teachers.
- WiSTEM2D Scholars Award Program (2017-on-going). This program is sponsored by Johnson & Johnson, providing bursaries and mentoring to female undergraduate students in any of the University of Limerick's STEM disciplines. The goal is to fuel the research passion of the selected women and inspire career paths in their respective STEM fields.

- Career Mathways Project. The project seeks to promote the awareness and engagement of the Irish public in STEM. The initiative aims to highlight the mathematics underpinning a variety of careers, as a way of enhancing student engagement across all STEM subjects.
- TiME (Time in Mathematics Education). The main aim of this project was to investigate such issues surrounding the allocation of time for mathematics instruction.
- Chain Reaction project focused on creating a sustainable approach to the use of scientific inquiry in the classroom using a cascading model to facilitate its impact. The focus in Ireland was to create a professional learning community (PLC) involving teacher educators, in-service teachers, pre-service teachers, practicing scientists and policy makers with the aim of developing a living educational theory of what teachers believe inquiry to represent in their own classroom context.
- Student Mathematical Preparedness for Third-Level STEM Degrees. The aim of this project was to explore students' mathematical preparedness for STEM education at tertiary level in the Irish context. This project also examined the existence and perception of interdisciplinary STEM education in preparing students for the transition to tertiary level STEM learning.
- CASTeL is Ireland's largest research centre in Science, Technology, Engineering, and Mathematics (STEM) education based at Dublin City University. CASTeL's mission is to support the development of STEM learners from an early age and thus enhance the scientific, mathematical and technological potential of Irish society. CASTeL is known for its leading role in international STEM education initiatives. Many of these focus on inquiry-based learning, in which problem solving and experimentation are based on students' curiosity and observation, allowing them to make sense of the world through critical thinking and reflection.
- Assessment of Transversal Skills in STEM (ATSSTEM) is a project of innovative policy experiments, which is carried out in 8 EU countries and includes a partner network of 12 educational institutions. ATSSTEM is committed to providing teachers and students with effective and necessary digital assessment approaches to develop the cross-cutting skills of second-level students in STEM (Science, Technology, Engineering and Mathematics). The project also aims to ensure that policymakers have a deployment strategy to create a creative learning environment appropriate to their national or regional context.
- ENERGE – Energizing Education to Reduce Greenhouse Gas Emissions. ENERGE is committed to achieving a minimum 15% reduction in total energy consumption in 12 schools with demonstration sites during the project period and will engage and enable management, teachers, students and support staff (the entire school ecosystem) to reduce energy consumption through the development of a new website. platform tailored for various stakeholders in the school ecosystem.

- Let's Talk about STEM is a pilot project, funded by Science Foundation Ireland, and led by DCU's Institute of Education in conjunction with the Centre for the Advancement of STEM Teaching & Learning (CASTeL) in DCU. This project is a collaboration between researchers in psychology and science and technology education to implement a pilot program to tackle the under-representation of women in science and technology, focusing on the early involvement of girls in science.
- Maths4All.ie, funded by SFI Discover, is a website designed for and with teachers. It contains activity plans, continuous professional development materials and video clips based on activities carried out in Irish primary and preschool classes. The website offers a video-based approach to continuous professional development and modules relating to mathematical tasks, talk and the use of play and picture books are available.
- 3DIPHE – Three Dimensions of Inquiry in Physics Education, an ERASMUS+ project focused on different levels of inquiry relevant for physics education: 1) Inquiry based learning for pupils; 2) Practitioners' inquiry for teachers; 3) Inquiry of coaching for partners; 4) Educational research design of 3DIPhE. The goals of the project are to establish professional learning groups (PLG) of teacher practitioners and train them to inquire about their own practice of inquiry-based learning (IBL).
- Open Schools for Open Societies project supports a large number of European schools to implement Open Schooling approaches by a) developing a model that promote such a culture, b) offering guidelines and advice on issues such as staff development, redesigning time, and partnerships with relevant organisations (local industries, research organisations, parents associations and policy makers), and c) suggesting a range of possible implementation processes from small-scale prototypes through to setting up an "open school within a school" or even designing a new school while it is testing and assessing them in more than 1,000 school environments in 12 European countries. The project aims to describe and implement at scale a process that will facilitate the transformation of schools to innovative ecosystems, acting as shared sites of science learning for which leaders, teachers, students and the local community share responsibility, over which they share authority, and from which they all benefit through the increase of their communities' science capital and the development of responsible citizenship.

Further STEM activities in Ireland promoting best practice

Further STEM activities evident in Ireland to support and further best practices include;

- Smart Futures. This is a selection of various educational activities for schoolchildren and students that allow them to understand the meaning of STEM education.
- SciFest programme consists of a series of one-day STEM fairs for second-level students. The aim of the programme is to encourage an interest in, and love of, the STEM subjects.

- Tech Week is a nationwide series of events, showcasing and celebrating Ireland's application on technology which provides a platform for students to learn, share ideas and create connections to enhance our future world.
- The Festival of Curiosity is Dublin's annual international festival of science, arts, design and technology with new digital, virtual and blended formats for people of all ages to explore and discover science, arts, design and technology in playful new ways.
- STEM in the Midlands involves Accenture STEM professionals visiting schools in the Midlands and presenting STEM materials as well as explaining what Accenture has to offer. As a board member, one of the Accenture professionals is involved in the planning and direction of the organisation.
- CoderDojo, initiated in 2016 by Accenture, which set up its first CoderDojo coding club for a group of energetic young people, with a team of enthusiastic mentors from The Dock. Accenture continues to run the club for beginners to advanced learners, aged 7-17, through CoderDojo, in the Accenture offices in Dublin. CoderDojo offers a number of topics for children such as Scratch, Lightbot and Robotics, where they learn how to code, develop websites, create apps and games.
- Girls Only TY Week is a weeklong Transition Year work experience programme, for girls only, with the aim of encouraging them to think about choosing STEM subjects for Leaving Certificate and studying STEM career in college. 15 Female TY Students attended. After the week finished all girls who attended agreed that they would consider a career in STEM for the future and would now consider STEM subjects for the Leaving Certificate.
- CWIT and Teen Turn is a non-profit organisation run completely by volunteers. This organisation strives to give teenage girls from disadvantaged areas or schools the ability to explore technology and STEM and in turn choose to study these subjects at secondary school and university. Connecting Women in Technology (CWIT) is a network of technology companies working towards the common goal of attracting, retaining and promoting females in the technology sector. Teen Turn had connected with CWIT in the lead up to the first Technovation Challenge in Ireland (Jan – Apr 2018).
- Intel Ireland Balloon Rocket Launch initiated by Intel Ireland, who reached out to 16 local primary schools with the aim of engaging third class students in an appropriately levelled science and engineering lesson, using inexpensive and widely available materials to demonstrate a scientific principle and the fundamentals of experimentation in an accessible and interesting way.
- Intel Ireland Mini-Scientist, Intel engaged with schools in the locality and also encouraged employee volunteers to encourage the competition in schools where they had an existing relationship. Schools are invited to complete an online registration form for entry (www.intel.ie/miniscientist), participating schools divide students into teams of 4 to work on projects relating to STEM and are then invited to host an exhibition of the projects at the school, with Intel

providing the adjudicators and prizes. Winning projects from each school progress to regional and then a national final.

- Introducing Students to Coding – Google CS First, is a 6-week programme, led by volunteers from Google, to give 4th class students (ages 9-10) at an all-girls primary school (with disadvantaged school status) their first taste of learning how to code. Staff from the Google office volunteered 1 hour per week to go to the school and support the students through structured lessons on CS First - Google's free curriculum to teach coding with Scratch, a block-based programming language.
- Ericsson INFUSE, Ericsson Athlone INvesting in FUture Software Engineers or INFUSE, is a range of initiatives that focus on creating enthusiasm and interest around Science and Mathematics. The INFUSE program encourages interaction with the students at a young age in order to avoid the negative stereotypes of the career, especially for future female engineers.
- Fujitsu–Schools Business Partnership Programme initiated in 2011 by Fujitsu Ireland and St. Joseph's School, Rush, partnered together as part of Business in the Community Ireland's (BITCI) Schools' Business Partnership Programme. This programme aims to tackle the retention rate in post primary schools and gives young students an insight into the careers and options available in the STEM industry.

STEM Teacher training

STEM Teacher training in Ireland represents the quality of teaching of STEM subjects in schools, which has a direct bearing on the quality of learner experience and achievement. Thus, any approach that aims to improve STEM education in Ireland schools must treat STEM teacher education as a key priority. The importance of initial teacher education (ITE) in STEM lies in challenging and deepening student teachers' beliefs about the learning process, in developing their understanding of the nature of the STEM subjects and familiarising them with a range of teaching approaches. Teacher knowledge is usually viewed as having three strands: subject matter knowledge (SMK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK) (Shulman, 1987). SMK concerns knowledge of content (e.g., knowledge of mathematical or scientific concepts, mathematical or scientific reasoning etc.). PK relates to knowledge of pedagogy and is generally subject independent (e.g. sociological or psychological aspects of education). PCK is the interplay between content and pedagogy, that is, the link between knowing something and facilitating others to learn it. It is expected that, as pre-service teachers progress through their preparatory programmes, these different forms of knowledge become more tightly interconnected.

Continual Professional Development

Professionally qualified teachers are encouraged and supported to engage in Continual Professional Development (CPD). The Professional development service for teachers (PDST) is Ireland's largest single support service offering professional

learning opportunities to teachers and school leaders in a range of pedagogical, curricular and educational areas. The PDST was established in September 2010 as a generic, integrated and cross-sectoral support service for schools. The establishment of the organisation was synonymous with the amalgamation and restructuring of a number of stand-alone services which now operate under the PDST providing their services to schools in the context of PDST's overall vision and mission. The work of the PDST contributes to school improvement by fostering reflective practice through the school self-evaluation process and through the ongoing development of teachers and school leaders through a range of CPD models. Amongst the priorities for the Department of Education and Skills (DES) for the coming years is the implementation of proposals to improve Literacy and Numeracy in both primary and post-primary schools. Other key priorities include supporting school leadership, school self-evaluation, assessment, ICT for teaching and learning, inclusion, health and wellbeing and post primary subjects and programmes. These priorities inform the work of PDST and are addressed through the work of individual teams across the organisation.

Chapter 4: STEM Education: Best practices in Türkiye

Gultekin Cakmakci, Hacettepe University, Türkiye

STEM education has recently become an area of increasing interest in Turkey. For instance, recent policy documents and science curricula emphasise on interdisciplinarity in education. There are several STEM activities and STEM professional development programs. In collaboration with different stakeholders several STEM activities and PD programs have been carried out. There are several STEM Labs at universities and science centres, which offer STEM teacher training programs and STEM enrichment programs for different age groups.

Public Engagement of STEM

In Türkiye, there are a wide variety of museums and science centres in different fields, but the first science centre, Feza Gürsey Science Center, was established in 1993 in Ankara. This science centre was established and run by Ankara Municipality. Partly based on this successful initiative, other municipalities in different cities and towns started to do public engagement activities in science and technology. The Turkish Supreme Council for Science and Technology (SCST) plays a critical role in setting the agenda and policies in science and technology. At its 23rd meeting on 27 December 2011, the SCST set a roadmap to promote science and technology among the public (SCST, 2011). In this meeting, TUBITAK, in cooperation with local authorities, was given the main role to establish science centres around the country to enhance children's interest and curiosity towards science and technology. TUBITAK aimed to complete a science centre in several metropolitan cities. Bursa Science and Technology Center, Konya Science Center, Kocaeli Science Center, Elaziğ Science Center, Kayseri Science Center and Üsküdar Science Center were funded by TUBITAK and their respective local municipalities. The local municipality is mainly responsible for the establishment of the science centre and TUBITAK is mainly responsible for the development of exhibitions, training of explainers and providing academic consultancy. Afterwards, the local municipality runs the centre.

Besides, there are several science and art centres in Türkiye.

Science and Art Centers

Currently there are 355 Science and Art Centres in 81 cities with a population above 67,375 students[6]. These centres are designated for gifted and talented students. There is a huge demand for these centres; therefore, through an examination, primary

[6] https://www.meb.gov.tr/meb-bilsem-sayisinda-hedefini-asti/haber/26129/tr

school students (up to Grade 4) are placed in three fields (music; a 'general talent' field including science history, geography, etc.; and visual art) according to their talent. The nature of diagnostic tests for the selection of students has been criticised as has the fact that these centres are only for gifted and talented students. There have been public demands for science and art centres for all children no matter what interests and abilities they have. These science and art centres are run by the Ministry of Education and are free of charge for students who pass the entrance exam. These students can attend their centres until they graduate from high school. They take courses and extracurricular activities and projects at the centre around 8 hours per week during school terms. They attend the centre at weekends or weekdays based on their school timetable.

There are non-profit initiatives in the field of public engagement of STEM in Türkiye. The Turkish Technology Team Foundation[7], STEM & Makers Fest/Expo[8] and Maker Faire[9] are among them. The Turkish Technology Team (T3) Foundation, founded by several entrepreneurs, supports educational projects and technology start-ups. They organise science engagement activities for primary and high school students and provide several support programs for university students and grants for young tech start-ups. The T3 Foundation aims to support 1001 Technology Teams and 1001 Technology Ventures by 2023.

STEM & Makers Fest/Expo aims to promote public engagement with STEM. So far, more than 250,000 participants from different age groups have engaged with STEM & Makers activities. The festivals have been held in 13 different provinces and the number of these provinces and people is increasing day by day with your contributions. STEM & Makers Fest/Expo has been organised in collaboration among universities, schools, local authorities and industry. STEM & Makers Fest/Expo is a member of the European Science Engagement Association (EUSEA)[10].

EUSEA is an international knowledge-sharing platform and accelerator of innovation in the fields of public engagement. The association addresses experts involved in the design, organisation and implementation of public engagement activities across Europe. EUSEA is an active consortium member in projects funded by the European Commission and supports partners in European funding policies.

In times of rapid changes in scientific institutions and society at large, science festivals and public engagement activities offer much more than "edutainment". Collaboratively designed engagement activities can build bridges – between science and society, researchers and citizens, policy makers and innovators. EUSEA initiates and supports

[7] https://www.t3vakfi.org/
[8] https://stemandmakers.org/
[9] https://makerfaire.com/
[10] https://eusea.info/

many of these activities as a strong partner, striving to foster public engagement that makes an impact across Europe.

Deneyap Technology Studios

Deneyap Technology Studios[11] was launched in July 2017 within the Technology Team Foundation of Turkey (T3 Foundation) within the scope of the "Technology Stars of the Future" program in order to train future engineers, technology entrepreneurs and technology leaders for a fully independent and strong Turkey.

Students in middle school (4th grade and 5th grade) and high school (8th grade, 9th grade and high school preparatory class) who want to be included in the Future Technology Stars Program complete their online applications within the application period announced on our website. Applicants go through a two-stage selection process consisting of a 60-question exam and a project assignment in the fields of Mathematics, Science, Algorithm and General Culture. Students who successfully complete the process within the determined quota are included in a 36-month training program at Deneyap Technology Workshops. All resources are available at: https://deneyapturkiye.org/yayinlarimiz.html

The instructor staff, who train the Technology Stars of the Future, consists of undergraduate or graduate university students, graduates, teachers and field experts working in the sector. Since the training is application-oriented, there are two instructors, an engineer and a teacher, in each classroom. There is a psychology intern in the classrooms who observes the instructors and students on a weekly basis in order to monitor that the training is being carried out efficiently.

STEM PD Initiatives

STEM PD Community of Practice (STEM CoP)[12], founded in 2019 as an outcome of the STEM PD Net project, is an independent body of network. STEM CoP aims to bring together researchers, practitioners and stakeholders from around the world to discuss issues related to STEM Education. STEM CoP develops STEM Curricula and runs STEM PD programs in different countries. STEM CoP also publishes journals and books in STEM education. STEM CoP organises “International STEM Education Conference” and “International STEM Teachers Conference” and its social media channels provide resources to teachers, initiating an online forum for teachers and lecturers. Journal of STEM Education[13] is among these initiatives. The journal is

[11] https://www.deneyap.org/
[12] https://www.stempd.net/
[13] https://dergi.stempd.net/stem-ed

published twice a year. Articles related to formal, informal, and non-formal environments, including application examples related to STEM education can be published in the journal. The publication language of the journal is English. The journal aims to be a journal that reflects the interests and needs of everyone interested in STEM teaching. Articles should include implementation examples that can be used by teachers working at the K-12 level, academics teaching at the undergraduate/graduate/doctorate level, and instructors working in informal environments such as science centres. The studies of the journal include a short video of the phenomenon that dealt with the activity addressed in the study. The focus of the video is on the content and working process of the prototype, code, material, etc. developed.

There are several STEM Labs at universities and science centres, which offer STEM teacher training programs and STEM enrichment programs for different age groups. Hacettepe University STEM & Maker Lab[14] is among them. Hacettepe STEM & Maker Lab[15] was established in 2009 has involved in several EC FP7, Horizon 2020 projects (e.g., S-TEAM, SAILS, MaScil, MOST), Horizon Europe, and Erasmus+ projects (STING, ENSITE and INSTEM). Hacettepe STEM & Maker Lab is one of the founding members of the ICSE (International Centre for STEM Education)[16]. ICSE is an internationally connected research centre that is located at the University of Education in Freiburg, Germany. The ultimate aim of ICSE is to help improve STEM (Science, Technology, Engineering and Mathematics) education across Europe through practice-related research and its transfer into practice. The work of ICSE and its partners focuses on the following six areas: inquiry-based learning, real-life contexts, connections to the world of work, interdisciplinary STEM teaching, socio-scientific issues, diversity in classrooms and gender aspects in STEM teaching. In order to support an implementation of these elements in STEM teaching, three aspects are central to ICSE: practice-related research, working on the national as well as international level and cooperating with key actors from the field of STEM education.

STEM education in collaboration with industry and different stakeholders

Turkish STEM Alliance[17], founded in 2015, is an independent body of networks for promoting public engagement with Science, Technology, Engineering and Mathematics (STEM). It unites STEM practitioners, researchers, policy makers and the public to enhance the quality of STEM education and broaden participation in STEM. The Turkish STEM Alliance consists of several different members from science centres, science museums, PD centres, NGOs, STEM centres, companies, research

[14] https://hstem.hacettepe.edu.tr/en
[15] https://www.youtube.com/channel/UCeJjkCHr0FA5fEuDGZHWwyw/about
[16] https://icse.eu/
[17] https://www.stemalliance.center/

centres and public organisations. The Turkish STEM Alliance is a member of the EU STEM Coalition[18].

The EU STEM Coalition is an EU-wide network that works to build better STEM (Science, Technology, Engineering, Mathematics) education in Europe. Our goal is to shape STEM education policies and practices that foster economic growth, opportunity and well-being for all.

Together with policy makers, education providers and industry, we work on promoting new ways of delivering education and finding and sharing evidence-based solutions to skills mismatch in STEM. From reducing shortages of STEM skilled people to fostering new ways in which educational institutions, companies and governments can cooperate, we provide a unique forum and knowledge hub for data and analysis, best-practice sharing and direct support.

The EU STEM Coalition's main goal is to facilitate best-practice sharing between countries and regions. Through a wide variety of activities and resources we bring together policy makers and policy shapers to exchange ideas, share experiences, and develop new approaches across a range of areas related to STEM education and labour market. Our activities include annual conferences, thematic working groups, webinars, peer-learning activities and online repositories. In addition, the EU STEM Coalition provides direct support in the development of new initiatives, organisations and strategies based on existing best-practices. Its main support instruments are:

Policy briefings: Policy briefings are custom, tailored recommendations focused on a single issue or challenge in a country or region.

Task Forces: Task Forces are a longer-running series of support actions aimed at assisting a country, region or other stakeholder in the development of new (STEM) skills strategies, platform organisations and implementation programmes.

Roundtables: The ‘roundtables' bring together key-stakeholders (e.g., employer organisations, engineering associations, education institutions, etc.) to identify bottlenecks in the (STEM) education pipeline and develop recommendations based on existing best practices.

[18] https://www.stemcoalition.eu/

Chapter 5: STEM best practices in Kazakhstan: L.N. Gumilyov Eurasian National University

Meruyert Serik & Ainur Zhumadillaeva, L.N. Gumilyov Eurasian National University, Kazakhstan

The Erasmus + project "Integrated approach to the training of STEM teachers" at L.N. Gumilyov ENU began its work in 2019.

The main objective of the project: To improve the quality of TRAINING of STEM teachers at partner universities in accordance with the Bologna Regulations and the needs of the knowledge economy.

Objectives of the project: Development of MASTER's programs STEM Teacher Training based on an integrative approach (for primary school teachers and STEM teachers at the high school level and STEM teachers in universities);

Creation of regional STEM resource centers providing consulting and training services;

Training teachers in new pedagogical skills.

Impact at the institutional level: Within the framework of the project, the L.N. Gumilyov ENU developed an educational program 7M01525-"STEM Education" in the direction of "Training teachers in natural science subjects" and in the 2020-2021 academic year there was an admission to this educational program.

Under this program, undergraduates are being trained at the expense of state grants through the Ministry of Education and Science of the Republic of Kazakhstan, which in our opinion indicates the further stability of the OP.

The faculty has created a center "STEM Education", which has equipment and computer equipment for conducting classes.

During the implementation of the project, interaction with other educational organisations has been strengthened. Interviews were held with teachers on the implementation of STEM education in schools. At this time, "Nazarbayev Intellectual Schools (NIS)" in Astana is involved. Also, before the development of the OP, a survey was conducted among teachers of schools in the city. Astana. Their views were taken into account in terms of strengthening the content of the OP.

NIS teachers proposed the introduction of the subject "Robotics" into the content of the educational program, since in the named school this subject is conducted with elements of STEM. NIS students won prizes in international robotics competitions. It should be noted that one of the members of this project conducts classes in NIS.

Impact at the international level.

A network of universities-partners of the project participants has been created to exchange experience and best practices in the field of STEM training within the Republic of Kazakhstan and with the countries of the Russian Federation and the EU.

Took part in the work of webinars conducted by project coordinators. Issues were discussed on the implementation of activities according to the plan, on the admission of students for the 2020-2021 academic year. One of the main issues is the development of an educational program and modules of disciplines.

In the online mode, with the participation of partner universities using a Google document, an OP structure was drawn up, which considered the process of student mobility.

The development of a STEM master's degree based on international educational standards contributes to the development of the education system of the Republic of Kazakhstan and brings it to the international level.

In the online mode, with the participation of partner universities using a Google document, an OP structure was drawn up, which considered the process of student mobility.

The development of a STEM master's degree based on international educational standards contributes to the development of the education system of the Republic of Kazakhstan and brings it to the international level.

There is a dissertation council at the department. There is a topic on the scientific and practical foundations of the introduction of STEM-learning in the educational process of the university.

To develop an OP for the training of teachers in the STEM direction, all partner universities of the project were involved.

On June 24-26, 2019, a meeting was held with foreign partner universities within the framework of the Erasmus + program on the project "Integrated approach to the training of STEM teachers" at the University of Limerick (Republic of Ireland). The purpose of the meeting is to study the best EU practices and methodologies in the

development of a unique master's program for the training of STEM teachers based on an innovative integrated approach in accordance with the Bologna Regulations https://enu.kz/ru/info/novosti-enu/57535/?sphrase_id=3831134.

In the online mode, with the participation of partner universities using a Google document, an OP structure was drawn up, which took into account the process of mobility of students. For training on mobility, the 3rd semester was chosen, so the content of the educational program of the 3rd semester will contain general modules of disciplines, and in the first and second semesters of the program, subjects offered by its university were included. Due to the situation related to the pandemic, the mobility of students did not take place. The developed OP was approved by the Commission from Europe.

On 29.04.2020, there was a round table on the compilation of OP with colleagues from partner universities:

- L.N. Gumilyov Eurasian National University (ENU, Republic of Kazakhstan); M.O. Auezov South Kazakhstan State University (SKSU, Republic of Kazakhstan);
- S. Amanzholov East Kazakhstan State University (EKSU, Republic of Kazakhstan);
- Southern Federal University (SFedU, Russia);
- Immanuel Kant Baltic Federal University (IKBFU, Russia)
- Belgorod State National Research University (BelSU, Russia).

In Google-Drive, the structure of the OP was compiled:

In the OP "7M01525-STEM Education" developed by L.N. Gumilyov ENU(https://fit.enu.kz/storage/7%D0%9C01525-STEM-2022.pdf), there are only 120 ECTS, of which updated disciplines taking into account the practice of 104 ECTS (87%) (52 credits updated disciplines, 52 - various types of practices), not updated disciplines 16 ECTS (13%).

Name of discipline	TotalECTS	With practice	Without practice
Not updated disciplines	16	13%	24%
Updated and new disciplines	52	87%	76%
Research practice	12		
Research work of the master student	24		

Registration and defence of the master's thesis	12		
Pedagogical practice	4		
	120	100%	100%

The title of the program: «7M01525–STEM Education»

Module name and code	**Name and code of discipline**	**Number of ECTS credits**	**Semester**
Introduction to STEM in Computer Sciences	Introduction to STEM	5	1
	STEAM-education as a universal teaching tool	5	1
	STEM Education in Computer Sciences	5	1
COMS 53002 Introduction to STEMin Sciences	STEM LearningPolicy	5	1
	STEAM education	5	1
	Science and STEM	5	1
STEM-Robotics	Programming microrobots	5	2
	Mindstorms Programming robots on the platform Mindstorms	5	2
Methodology of STEM education in Computer Sciences	Methods of teaching Computer Science using STEM	5	2

	Maintenance and support of STEM projects	5	2
STEM teaching methods in the Science	Methods of teaching natural science subjects using STEM	5	2
	Management and support of STEM projects for science disciplines	5	2
Teaching methods in the framework of the integrative STEM approach in computer	Big data	5	3
	The Internet of Things and Intelligent Systems	5	3
Teaching methods for integrative STEM for natural Sciences	Data analysis	5	3
	Academic writing and research integrity	5	3
Modern learning technologies	Cloud technologies	5	3
Teaching methods in the framework of the integrative STEM approach in computer science	Digitalization of education	5	3
Teaching methods for integrative STEM for natural Sciences	Parallel Computing	5	3

The disciplines of 3 semesters will have to be chosen at the end of the academic year. Every year, the content of syllabuses is updated by 30%. For 2021-2022, changes were made with the wishes of employers. A course on circuit engineering has been developed. Topics in the circuitry course will be reflected in the content of the SOI 5203 course - "STEM Education in Computer science". This course is in the module of basic disciplines and elective course (DB KV). The volume of the course is 5 credits (15 lectures, 30 practical classes and 105 SROs).

The content of this course is reflected in the catalog of elective disciplines (QED). For example, we give an example the content of this subject from the catalog of elective disciplines:

Elective courses catalogue of the education program «7M01525– STEM Education» for the students of the 2020-year admission

№	Cycle of the course	Name of the course	Credit	Annotation	Prerequisites
Semester 1					
University component					
5	BD EC	STEM Education in Computer Sciences	5	The course aims to expand the professional competencies required by a computer science teacher using a comprehensive STEM approach to learning.	Methods of Teaching Informatics

According to the EP "7M01525-STEM education", undergraduates are trained in a multilingual group. In the first year, the discipline "Methods of teaching computer science using STEM" is conducted in English, the rest, at the choice of undergraduates, are conducted in the Kazakh language.

Stakeholders of educational institutions represented by scientists, school principals and students take part in the compilation of the OP. Such cooperation between the department and employers showed the lack of formalism in the training of personnel. The organisation of education understands that qualitatively made adjustments to the OP allow students to qualitatively master a number of professional competencies.

NIS teachers have proposed the introduction of the subject “Robotics” into the content of the educational program, as in the named school this subject is taught with STEM elements. NIS students won prizes in international robotics competitions. Note that one of the members of this project conducts classes at NIS.

The department, having switched to close cooperation with employers, where the share of the main OP developed with the participation of employers in the total number of programs implemented, was ready not only to improve the mechanisms of social partnership, but also to become a more open educational environment.

I received from her employer - acting director of the State Institution «School-Lyceum № 56» Baygaziev R.F. , Professor of the Department of the Al-Farabi Kazakh National University Kerimbayev N.N., Associate Professor, Scientific Secretary of the I. Altynsarin NJSC Mukasheva M.U. at the OP «7M01525-STEM Education» in the direction of «7M015-Teacher Training in Natural Science Subjects».

New teaching methods are changing the educational environment around the world and are driving the improvement of student achievement. The following methods have been used to teach and teach STEM:

1. an integrated teaching method aimed at the development of new technologies based on the combination of mathematics, physics with computer science and capable of innovative thinking, to meet the need for well-trained teachers;
2. binary lesson method - a method in which the interrelated material of two or more subjects (courses, disciplines, etc.) is studied;
3. a method in creating a fair and inclusive environment; through improved access to STEM programs, there will be opportunities to get a promising education and highly profitable work for marginalised groups (ethnic and national minorities, residents of rural or remote areas, girls and women, etc.);
4. teaching method - from practice to theory;
5. a practice-oriented method that awakens in children a natural craving for research and discovery, which is based on interdisciplinarity and the integration of five scientific fields into a single learning system to solve specific problems taken from real life.

- Project-Based Learning Method – A project-based or complex task-based learning method is today the best didactic guarantee for the effective development of key skills, as well as the acquisition of knowledge about the content of the curriculum.

Cooperative learning method is the concept of a simple way of learning together, a methodology that teachers use to group students together and thus influence learning in a positive way.

5 undergraduates have graduated, now 3 undergraduates are studying in the 2nd year, and 6 undergraduates are studying in the first year.

A set of students is planned at the expense of state grants, which in our opinion will ensure the sustainability of the educational program, an order was made to the Ministry of Education and Science of the Republic of Kazakhstan.

A memorandum on double-degree education was concluded between L.N. Gumilyov ENU of the Republic of Kazakhstan and the South Federal University of the Russian Federation, but due to the political situation this program has been suspended.

There is a STEM center where training sessions are held.

Further, we note that for the implementation and promotion of the project, a meeting of the team was held weekly on a certain day (Wednesday, 15.00) according to the plan.

On October 20-21, 2020, the participants of the project "STEM in Education" took an active part in the International Online Forum "Global in The Regional: Kazakhstan in the Bologna Process and EU Projects" and in the Erasmus+ Exhibition of the Results of Projects.

This online forum was dedicated to the 10th anniversary of Kazakhstan's participation in the Bologna process and the 25th anniversary of participation in the EU Tempus and Erasmus + programs. The meeting was attended by the Head of the Delegation of the European Union to Kazakhstan.

On 24.02.2021, an international conference "STEM-Education" was held based on L.N. Gumilyov ENU
https://enu.kz/ru/info/novosti-enu/62263/?sphrase_id=3831134:

Objectives of the conference: identification, support and dissemination of the best pedagogical experience of educators of the education system, development of their creative potential and professional skills in the direction of STEM.

Conference participants: teachers of higher educational institutions, directors and teachers of schools, teachers of colleges, institutes of advanced training of educators, regional methodological centers and inter-school methodological centers are invited to participate in the conference.

There were speeches in three sections:

1. STEM in teaching computer science;
2. STEM in a comprehensive school;
3. STEM in education: the experience of foreign teachers.

Various events were timed to coincide with STEM Day. On 12.01.2021, an educational and methodological seminar was held to improve the quality of education. In the implementation of external quality assurance, a seminar was planned and held with the participation of the L.N. Gumilyov Eurasian National University, the Belgorod State National Research University of the Russian Federation, the M. Auezov South Kazakhstan State University, the S. Amanzholov East Kazakhstan University with the

title "STEM-training and methods of conducting practical classes, where reports were made by the teaching staff of universities. Such topics as "Prospects for STEM education in the Republic of Kazakhstan", "Methods of building feedback with students", "Means of creating video fragments of the lesson", "Creating IDLs (interactive worksheets)", "Internet of Things and the use of the Packet Tracer simulator" 6, were considered.

15.10.2021 in connection with Erasmus Days 15.10. In 2021, an exhibition of projects within the framework of Increasing the Potential of Higher Education was held at L.N. Gumilyov ENU, as well as an information day on the Erasmus + credit mobility program. In the work of the exhibition, I took part with all interested persons, including coordinators for international cooperation, teaching staff and teaching faculty.

Members of the team of the project "Integrated approach to the training of STEM teachers" presented information about STEM education on the poster, information materials on STEM education, booklets of the educational program "7M01511-Computer Science", certificates of participation of teaching staff in the work of various conferences, seminars and festivals were also presented.

As part of the "STEM Day" on 25.01.2021, an international scientific seminar "STEM education in modern higher education" was organised with the participation of Project members and foreign scientists.

In On December 22, 2021, on the basis of Astana IT University in honour of the 30th anniversary of Independence of the Republic of Kazakhstan, the National Office of the Erasmus + Program in Kazakhstan together with the Department of Higher and Postgraduate Education of the Ministry of Education and Science of the Republic of Kazakhstan and the Delegation of the European Union in Kazakhstan with the support of the European Executive Agency for Education and Culture of the European Commission (EACEA) held a poster session of the results of the Erasmus+ air defence projects in Kazakhstan. The event was held in a mixed format (30 participants offline, the rest online). Members of the National Team for the Reform of Higher Education of the Republic of Kazakhstan, members of project teams, representatives of L.N. Gumilyov ENU, including members of the project 598367-EPP-1-2018-1-SE-EPPKA2-CBHE-JP /STEM "Integrated Approach to STEM Teacher Training".

The purpose of the poster session is to familiarise a wide range of stakeholders with the achievements and results of Erasmus + projects in order to enhance their multiplicative effect and disseminate experience. During the session, the teams presented their experience in implementing projects, their results and impact at the individual, institutional and national levels, and the potential for their sustainability.

The participants were also familiarised with information about the rules of the Erasmus+, application competition, the selection procedure and priorities, as well as

give practical advice to those wishing to participate in Erasmus+ events (Actions "Increasing the potential of Higher Education", "Academic Mobility", "Jean Monet", "Development of Erasmus Mundus - Erasmus Mundus Design Measures"). The program of the Information Day is published on the website www.erasmusplus.kz.

On 16.03.2022, as part of the implementation of the coaching project with other STEM projects, the project members participated in the work of the University Scientific and Methodological Scientific Seminar of the Belarusian State Pedagogical University named after Maxim Tank. The organiser of this event on the part of L.N. Gumilyov ENU is Associate Professor Davletova A.

The national seminar held at L.N. Gumilyov Eurasian National University (ENU) on March 29, 2022. The seminar focused on raising awareness of master's training under the project "Integrated Approach to STEM Teacher Training" of the Erasmus + program.

The seminar was attended by the teaching staff - members of the project "Integrated approach to the training of STEM Teacher Training" of the L.N. Gumilyov ENU, S. Amanzholov East Kazakhstan State University and M.O. Auezov South Kazakhstan State University.

The results of work on informing the public about the work of the project were discussed and plans for further work were announced. The report on the coverage of the activities of the project members was given by the coordinator of the ENU project Serik M. She highlighted that activities of members were published on the pages of republican newspapers and magazines, as well as on the pages of social networks Instagram, Facebook and YouTube.

Professor Serik M. published a monograph, where the content of one of the chapters is devoted to STEM training of students.

An open day was held at the university on March 23, 2022, where the results of the students of the Educational Program "7M01525-STEM Education" were presented. Also, the ENU coordinator, Professor Serik M., acquainted the participants of the seminar with the ongoing career guidance work on STEM education. The Department of Computer Science has a dissertation council, where doctoral students study and engage with STEM problems. The coordinator, Vice-rector of the University, Rovnyakova I.V. spoke about the completed work on awareness of STEM education at the S.Amanzholov EKSU. At the end, the M.O. Auezov SKSU coordinator, associate Professor,Omasheva G. made a speech.

On 26.04.2022, within the framework of the Advanced Training Programs "STEM Approaches to SchoolIng", a seminar was held on the basis of L.N. Gumilyov ENU,

where participants from Belgorod of the Russian Federation, M. Auezov YuKU, S.Amanzhollov EKU, L.N. Gumilyov ENU spoke online.

From June 20 to June 30, 2022, a festival and a summer school were held to train e teachers in the direction of STEM under the Erasmus + program. Across the country, 1 19 participants applied for participation in the STEM festival and summer school. Including teachers, undergraduates, doctoral students. More than 25 undergraduates from Shymkent and Ust-Kamenogorsk came to Nur-Sultan for offline training and exchange of experience
https://enu.kz/ru/info/novosti-enu/66741/?sphrase_id=3787609.

The program of the summer school can be found here Program of STEM Festival & Summer school

Information letters to universities were sent earlier than a month ago. After online registration of participants, invitations were sent to them. 119 people were registered, since the summer school was organised offline, the number of participants was 47. The Erasmus + program paid for the travel expenses of participants from partner universities in the STEM project.

The summer school program meets the requirements of the direction of a modern school. Almost all areas of modern information and communication technologies are covered. The lecture materials were accompanied by practical work, as well as master classes on the topic and discussions on the state of the topic under consideration in a particular university. At the end of the summer school, certificates and letters of gratitude were presented.

Based on the results of the festival and the summer school, a video film was created.

In October 2022, project members took part in the coordination meeting of the project in Istanbul, where the implementation of the project plan was considered.

As part of the Integrated Approach to STEM Teacher Training (STEM) project under the European Erasmus + program, from November 25-27, 2022, in Nevsehir (Turkey), an event called “STEM project training and STEM & Makers Fest/Expo STEM & Makers Fest/Expo".

On the first day, November 25, 2022, there was a defence of projects from representatives of partner universities in Finland, Ireland, and Kazakhstan. Evaluation and consultation were given by experts from the partner universities, as well as by the main coordinator, Mr. Janerik Lundquist.

From the L.N. Gumilyov Eurasian National University, 2 projects were presented, accompanied by a professor of the Department of Computer Sciences, Doctor of

Pedagogic Sciences Serik M., and doctoral student of the Department of Computer Sciences Balgozhina G.B.

The first project was presented by the 1st year master student of the educational program 7M01525 "STEM education" Nyyazkhanov Madiyar, Project topic: "Smart Photobioreactor". Scientific consultants are Professor of the Department of Computer Sciences, Doctor of Pedagogic Sciences Serik Meruyert, doctoral student of the Department of Computer Sciences Nurgaliyeva Symbat.
The goal of the project is to create an algae photobioreactor that will use artificial intelligence to better process and produce biomass. This prototype is more stable, efficient, manageable and smaller than other bioreactor prototypes.

The second project was presented by a master student of the educational program 7M01525 "STEM education" Abdirey Laura. Project theme: "Forest firefighter robot". Scientific consultants are Associate Professor of the Department of Computer Sciences, PhD, Karelkhan Nursaule, doctoral student of the Department of Computer Sciences Nurgalieva Symbat.

The goal of the project is to use a neural network to detect forest fires from space. It transmits all the data to the second robot, the firefighter, which works completely autonomously from people. He goes to the point and puts out the fire with the help of special systems that record the area and intensity of the fire.

Stem Awareness-Raising activities are held ongoing.
Registered participants – 119, Offline participants – 47, Schoolchildren participants – 8, Speakers – 24 (Lecture-24 г. hour, Practice-38hour, Discussion-5hour, Master class-5 hour)

Career guidance is ongoing at the Faculty of Information Technology. Booklets made. The website of the Department of Computer Science, Instagram (Kafedra_inf) and Facebook http://www.facebook.com/inf.kafedra.3has information, pages on STEM education for career guidance. http://fit.enu.kz/subpage/kafedra-informatiki

Erasmus+ Website www.stem-project.org ,
website of the L.N.Gumilyov ENU University http://www.enu.kz/ru/sotrudnichestvo/mejdunarodnye-granty/erasmus-mundus/cbhe/novosti-proekta-stem/,
website of the Department of Informatics of L.N.Gumilev ENU https://fit.enu.kz/subpage/kafedra-informatiki ,
about projects - https://fit.enu.kz/subpage/mezhdunarodnoe-sotrudnichestvo-kafedry-inf ,
STEM learning experience- https://fit.enu.kz/subpage/nauchnaya-deyatel-nost-kaf-inf ,
Programm- https://fit.enu.kz/subpage/obrazovatel-nye-programmy-kafedra-informatiki

achievements in STEM https://fit.enu.kz/subpage/obrazovatel-nye-programmy-kafedra-informatiki ,

reception and summer school-- https://enu.kz/ru/info/novosti-enu/66741/?sphrase_id=3787609

There is a dissertation council at the department. There is a topic on the scientific and practical foundations of the introduction of STEM-learning in the educational process of the university.

Chapter 6: STEM best practices in Kazakhstan: M. Auezov South Kazakhstan University

Gaukhar Omashova & Lyazzat Zhaidakbayeva, M. Auezov South Kazakhstan University, Kazakhstan

The introduction of STEM education in M. Auezov South Kazakhstan University began with the realisation of the Erasmus + program project "Integrated Approach to STEM Teacher Training" from January 2019.

The main goal of the project is to improve the quality of training of STEM teachers at partner universities in accordance with the provisions of the Bologna Declaration and the needs of the knowledge economy.

Specific objectives of the project:
- Development of master's programs for the preparation of STEM teachers based on an integrated approach;
- Creation of regional STEM resource centers providing consulting and interaction services;
- STEM Ambassador Training;
- Teaching teachers new skills.

Needs for STEM. The project team of M. Auezov South Kazakhstan University together with S.Amanzholov East Kazakhstan University and L.N. Gumilyov Eurasian National University has conducted a survey of three target groups in Kazakhstan intended to identify middle and high school (6-11th) students' attitudes towards STEM, specifics of teaching STEM subjects at school, STEM-focused courses at supplementary education institutions, STEM teachers' PD needs and prospects for integrated STEM approach implementation in Kazakhstan.

The project team has developed online questionnaires related to the target groups and survey's goals. The following are online questionnaires' links:
1) questionnaire for middle and high school students: https://docs.google.com/forms/d/1ZjZo6kg2lmKg7wOefs41z0OmMAT9LwmnOo-pmKeIw6s/edit
2) questionnaire for secondary school teachers of STEM-disciplines: https://docs.google.com/forms/d/1jdxlAQshBobrt-WWJbTMScrvHpjXi3m-DG9rJ_raheY/edit
3) questionnaire for STEM-teachers at supplementary education institutions: https://docs.google.com/forms/d/1D2qFppTF_v09jImy8c5DfbmWNsgOFNS3JJrOJTi6bMc/edit

Responsible executors of the project from M. Auezov South Kazakhstan State University translated the questionnaires into Kazakh. Questionnaires and Google forms were discussed at the meeting of the Working group (protocol № 2 dated 15.04.2019).The links to online questionnaires were sent to the project coordinators atS.AmanzholovEast Kazakhstan State University and L.N. GumilyovEurasian National University.

The distribution of these links to 90 e-mail addresses of educational organisations (departments of education, secondary schools, colleges and organisations implementing additional General education programs and courses in the field of STEM-education) was carried out by the responsible executors of the project from M. AuezovSKSU,Republic of Kazakhstan. ENU L.N. Gumilev, S. Amanzholov EKSU.The analysis of the survey results was carried out by the responsible executors of the project from M. Auezov SKSU., the results were evaluated by an expert sociologist, doctor of sociological Sciences E.S.Satymbekova.

Survey of middle and high school students' attitudes towards STEM in Kazakhstan

(based on the questionnaire for middle and high school students)

The goal of the survey is to identify the interest of students in STEM-disciplines (Chemistry, Physics, Biology, Geography, Technology, Mathematics, Computer Science) in Kazakhstan schools. 201 Kazakhstani schoolchildren from 20 settlements participated in the survey, including the cities of Nur-Sultan, Shymkent, Ust-Kamenogorsk, Pavlodar, Uralsk, etc.:11th grade students – 30,8%, 10th grade students – 28,4%, 9th grade students – 23,4%, 8th grade students – 17,4%.

Outputs of the survey:

The results of the survey show that Kazakh schools have just started to implement the basic STEM algorithms in secondary education, so the "new thinking" in this module should primarily relate to teachers retraining within M.Ed. program and PD training courses in the field of STEM education methodology and psychology.

The greatest interest of respondents to additional occupations and leisure centers are shown mainly in the following disciplines: Mathematics – 26,9%, Physics – 22,6%, Technology – 22,1%, Biology, Robotics, Design and 3D-modelling –19,2% on each, technical creativity (engineering) defines the importance of development of practical training programs for students in the above disciplines.

The analysis of the answers shows that the choice of disciplines by students is mainly related to the so-called «traditional» STEM-subjects (Math, Physics etc.), but not to the innovative STEM-subjects such as Robotics, Design and 3D modelling. This fact points to the absence of motivation by students in teaching innovative STEM-subjects, so the solution of this problem may be introduced in promotion of STEM-focused

events like STEM-days, STEM-weeks or STEM-festivals aimed to increase motivation in teaching innovative STEM subjects and to highlight their importance.

Judging from questionnaire' analysis, universities should create STEM-focused curricula (master's degree programs). The curricula should be aimed to reach the main goals of the STEM-approach implementation, to increase the motivation of students in teaching STEM-related subjects and to provide educational organisations with competent and skilled HR in the STEM-field.

Survey of specifics of teaching STEM subjects in school, STEM teachers' PD needs and prospects for integrated STEM approach implementation in Kazakhstan (based on the questionnaire for secondary school teachers of STEM-disciplines)

The goal of the survey is to study the specifics of teaching STEM-disciplines (Chemistry, Physics, Biology, Geography, Technology, Mathematics, Computer Science) in schools, to identify the PD needs as well as STEM prospects in Kazakhstan. 306 teachers from 20 settlements, including the cities of Nur-Sultan, Shymkent, Ust-Kamenogorsk, Pavlodar, Uralsk, etc. participated in the survey. The Highest percentage of participation falls on the city of Shymkent – 52.3%.

Outputs of the survey:

Respondents of the survey note that the main factors that negatively affect the motivation and quality of students' training in STEM-disciplines are the lack of modern educational and methodological support and modern educational equipment, special educational/laboratory equipment as well as low speed Internet connection in educational organisations. Apart from the shortcomings in teaching methodology, respondents point to a weak level of professional competence in the subject matter, psychological, pedagogical and technological training of STEM teachers, the lack of effective interaction between teachers, educational organisations, industrial partners in the implementation of STEM-disciplines, as well as low teacher motivation.

In general, teachers show a significant interest in STEM education, and therefore, it is necessary to develop and implement more in-depth training courses and programs for in-service teachers to adapt to a new model of STEM-education within the integrated approach.

M.Ed. Curriculum and PD training courses to be developed within the project should focus on the following pedagogical approaches, teaching methods and techniques indicated by the respondents as providing high students' motivation and good learning outcomes within the STEM subjects: PBL, IBL, differentiated learning, research and laboratory studies.

Survey of specifics of teaching STEM-focused courses at supplementary education institutions, STEM PD needs and prospects for integrated STEM

approach implementation inKazakhstan (based on the questionnaire for STEM-teachers at supplementary education institutions)

The goal of the survey: to identify opportunities in joint activities in the field of STEM-education with universities and schools, study of the features of the implementation of additional General education programs and courses in the field of STEM-education (technical creativity, programming, design and 3D-modelling, robotics, etc.) in organisations of additional education of children and youth in Kazakhstan.152 teachers implementing additional General education programs and courses in the field of STEM-education participated in the survey.

Outputs of the survey:

The results of the survey show the need to expand the training program of STEM-education in 3 main areas: theoretical training, psychological adaptation of teachers to new interdisciplinary modules, practical development and implementation of integrated STEM modules. It seems certain that the regional STEM learning resource center intended to provide teachers with T&L materials, PD training/M.Ed. courses and relevant equipment should become the core element of the regional STEM ecosystem.

According to the survey results the respondents of this focus group are particularly interested in the following deliverables of the project “Integrated approach to STEM teachers training”: STEM PD training courses for teachers, best practices in STEM education and STEM ambassador programs.

Conclusions

To sum up, the project team considers that:

1) the interest and attitudes towards STEM-disciplines by students in Kazakhstan could be expressed with the following statements: STEM teaching in schools is fundamentally relevant to satisfy the majority of students. However, STEM teacher training programs to be developed should consider techniques and practices of motivating students as well as using ICT/lab equipment and STEM tools while promoting laboratory work, interdisciplinary projects and studying real-world cases within the framework of students’ career preferences.

2) specifics of teaching STEM subjects in school and STEM-focused courses at supplementary education institutions in Kazakhstan is shown in such a way: teachers show a significant interest in STEM education, and therefore, it is necessary to develop and implement more in-depth training courses and programs for in-service teachers to adapt to a new model of STEM-education within the integrated approach.

3) STEM teachers’ PD needs and prospects for integrated STEM approach implementation in Kazakhstan are as follows: M.Ed. Curriculum and PD training courses to be developed within the project should focus on the following pedagogical

approaches, teaching methods and techniques indicated by the respondents as providing high students' motivation and good learning outcomes within the STEM subjects: PBL, IBL, differentiated learning, research and laboratory studies.

At the same time, it is necessary to develop STEM ambassador courses and carry out STEM events like STEM days & weeks, STEM festivals in terms to overcome the negative trends of participation' absence in STEM-focused activities and to increase the role of integrated STEM-approach in the whole educational area.

The analytical data of the survey were used for developing learning outcomes of master program

Development of master program. The program has been developed within the framework of the **European project Erasmus+ "Integrated Approach to STEM Teacher Training"** with the participation of the University of Limerick (Ireland), the University of Helsinki (Finland), Linkoping University (Sweden).

The educational program has been developed in accordance with the state mandatory standard of postgraduate education of the Republic of Kazakhstan. Learning outcomes are formulated based on the guidelines of the European Credit Transfer and Accumulation System (ECTS).

Name of the programme: "Physics and computer science with the basics of STEM learning"

Number of ECTS credits for the programme: 120

Aim/purpose with the programme: Training of highly qualified competitive masters who meet modern principles of teaching in the field of STEM education, based on leadership and an integrative approach to teaching and research.

Learning outcomes for the programme.

1. Deeply understand modern trends in education, features of STEM - training for the development of functional literacy of students.

2.Effectively use psychological and pedagogical technologies in professional activities necessary for the training, development and education of students, including those with special educational needs

3.Conduct training sessions professionally, actively using STEM technology to develop students' life skills.

4.Integrate and apply science and engineering practices into teaching, learning materials and assessment, demonstrating skills in analyzing, selecting and transforming information.

5.Reasonable to plan and manage projects at all stages of their life cycle, solving problems based on critical thinking, applying digital technologies and resources, using logical, systematic and sequential approaches

6.In cooperation with colleagues, plan and conduct research in the field of natural and pedagogical sciences to improve the practice of education, introducing the results of research into practical pedagogical activities.

7.Generate new ideas and solve professional problems, including interdisciplinary areas.

8. Critically determine the strategy of scientific, socio-pedagogical and communicative activities, making decisions and taking responsibility for the results.

Content of the programme

The curriculum content of the Master's degree is divided into six modules, which is done so according to the main focus of the program. The next types of activities are used in education: Lecture(L), Lecture with practice(LP), Practice(P), Seminar(S), Research seminar(RS), Laboratory work (LW).

Module 1: Module of Scientific and pedagogical training

It aims to provide a holistic overview of the history and philosophy of the development of science, problems and trends in higher education. The courses of this module are:

- History and philosophy of science (4ECTS,L,S);
- Foreign language (professional) (4ECTS,P);
- Higher School pedagogy (4ECTS,L, S);

Module 2: Methodology module
Methodology module is aimed at examining various didactic strategies of pedagogy to foster the innovative engagement of diverse learners. The courses of this module are:

- Methods of teaching the basic principles of physics (4ECTS,LP);
- Methods of Teaching educational robotics (4ECTS,LP);
- Modern practices of STEM education in physics (5ECTS, LP);
- Modern practices of STEM education in computer science(5 ECTS, LP).
- Methods and technologies of STEM education (5 ECTS, LP).

Module 3: Technology module

The Technology module is aimed at equipping future STEM teachers with conceptual knowledge of the STEM approach in education and digital skills to be employed for teaching different STEM subjects. The courses of this module are:

- Introduction to STEM (4ECTS,LP,S);
- Concepts of modern natural science (4ECTS;L,S)
- Online Educational Platforms (6ECTS,L,S);
- Digital technologies in education (6ECTS,L,S).
- Design and development of digital educational resources (6ECTS,L,S).
- Pedagogical practice (4ECTS, P).

Module 4: Leadership module

Leadership module is aimed at fostering leadership skills to prepare future teachers for ongoing improvement of the learning environment. The courses of this module are:

- Management Psychology (4 ECTS,L,S);
- Leadership and teamwork (6 ECTS, L,S);
- Project management (6 ECTS,L, S);

Module 5: Physics of high technologies module

Physics of high technologies module is aimed at equipping future STEM teachers with methodological, organisational, and research skills to be employed for teaching different STEM subjects.

- Technologies for converting solar and thermal energy into electrical energy(6ECTS,LP);
- Thermal radiation (6ECTS,LP);
- Physical foundations of high technologies (7ECTS,LP,S);
- Experimental physics (7ECTS,LP,)
- Intelligent robotic systems (7ECTS,LP,)
- Educational Robotics (7ECTS,LP,)
- Cloud technologies (7ECTS,LP,)
- Augmented reality (7ECTS,LP,)

Module 6: Research work and final attestation module:

Research module is aimed at enabling students to become informed consumers of research and to develop skills to prepare them to carry out action research in their schools and organisations. The content of this module are:

- Research work of a master student, including an internship and a master's thesis (24ECTS,RS)
- Execution and defence of the master's thesis (12 ECTS,RS)

Creating a STEM center.
In 2021, a STEM center was opened at M. Auezov South Kazakhstan University. The aim of creating a STEM center is to provide training and consulting services for a wide range of stakeholders: teachers, students, non-formal teachers through training seminars and teaching materials online.

The equipment for the STEM center was purchased through financing within the framework of the project "Integrated Approach to STEM Teacher Training" of the Erasmus+ program.

In the STEM center, equipped with the necessary equipment for young researchers, students will learn to write programs, create websites and applications, design robots and master new technologies, using knowledge of the laws of physics, mathematics, chemistry, biology. Trainers trained within the framework of the project will conduct advanced training courses for teachers**.**

International Summer Online School "Modern Trends in STEM Education"

M. Auezov South Kazakhstan University held from July 27 to July 31, 2020 the International Summer Online School "Modern Trends in STEM Education" in the framework of the project "Integrated Approach to STEM Teacher Training" of the Erasmus + program for students of educational programs in the field of educational and natural sciences, engineering, technology and future STEM teachers. Within the framework of the summer school speakers from 7 HEI-s of the near and far abroad countries were invited, such as Linköping University(Sweden), University of Helsinki (Finland), Southern Federal University, Belgorod State University, A. I. Kant Baltic Federal University (Russia Federation) and L. N. Gumilyov Eurasian National University, M. Auezov South Kazakhstan University (Kazakhstan).

The online format of the school made it possible to attract more than **60** listeners for work of the school from two countries - Russia and Kazakhstan. Among the participants were university HEI teachers, school teachers, as well as potential applicants for a master's degree in STEM pedagogy.

Dissemination of the project results.

In order to disseminate the results of the project, 4 STEM weeks and 8 STEM days were held at M.Auezov SKU. As part of these events, participants shared their experience in the field of STEM education. During the STEM weeks and STEM days, the speakers introduced the audience to global trends in education, inquiry-based learning and project-based learning methods; master students of the educational program presented their projects in the following areas: 1) the use of simulators of laboratory work related to the topic under study; 2) designing laboratory work with your

own hands on the topic under study; 3) creation of simple models working on the principles of physics; 4) creation of simple robots.

STEM best practices in M. Auezov South Kazakhstan University

The introduction of STEM education in M.Auezov South Kazakhstan University began with the realisation of the Erasmus + program project "Integrated Approach to STEM Teacher Training" from January 2019.

The main goal of the project is to improve the quality of training of STEM teachers at partner universities in accordance with the provisions of the Bologna Declaration and the needs of the knowledge economy.

Specific objectives of the project:
- Development of master's programs for the preparation of STEM teachers based on an integrated approach;
- Creation of regional STEM resource centers providing consulting and interaction services;
- STEM Ambassador Training;
- Teaching teachers new skills.

Needs for STEM. The project team of M. Auezov South Kazakhstan University together with S.Amanzholov East Kazakhstan University and L.N. Gumilyov Eurasian National University has conducted a survey of three target groups in Kazakhstan intended to identify middle and high school (6-11th) students' attitudes towards STEM, specifics of teaching STEM subjects at school, STEM-focused courses at supplementary education institutions, STEM teachers' PD needs and prospects for integrated STEM approach implementation in Kazakhstan.

The project team has developed online questionnaires related to the target groups and survey's goals. The following are online questionnaires' links:

1) questionnaire for middle and high school students:https://docs.google.com/forms/d/1ZjZo6kg2lmKg7wOefs41z0OmMAT9LwmnOo-pmKeIw6s/edit
2) questionnaire for secondary school teachers of STEM-disciplines:https://docs.google.com/forms/d/1jdxlAQshBobrt-WWJbTMScrvHpjXi3m-DG9rJ_raheY/edit
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Responsible executors of the project from M. Auezov South Kazakhstan State University translated the questionnaires into Kazakh. Questionnaires and Google

forms were discussed at the meeting of the Working group (protocol № 2 dated 15.04.2019). The links to online questionnaires were sent to the project coordinators atS.AmanzholovEast Kazakhstan State University and L.N. GumilyovEurasian National University.

The distribution of these links to 90 e-mail addresses of educational organisations (departments of education, secondary schools, colleges and organisations implementing additional General education programs and courses in the field of STEM-education) was carried out by the responsible executors of the project from M. AuezovSKSU, Republic of Kazakhstan. ENU L.N. Gumilev, S. Amanzholov EKSU.The analysis of the survey results was carried out by the responsible executors of the project from M. Auezov SKSU., the results were evaluated by an expert sociologist, doctor of sociological Sciences E.S. Satymbekova.

Survey of middle and high school students' attitudes towards STEM in Kazakhstan

(Based on the questionnaire for middle and high school students)

The goal of the survey is to identify the interest of students in STEM-disciplines (Chemistry, Physics, Biology, Geography, Technology, Mathematics, Computer Science) in Kazakhstan schools. 201 Kazakhstani schoolchildren from 20 settlements participated in the survey, including the cities of Nur-Sultan, Shymkent, Ust-Kamenogorsk, Pavlodar, Uralsk, etc.:11th grade students – 30,8%, 10th grade students – 28,4%, 9th grade students – 23,4%, 8th grade students – 17,4%.

Outputs of the survey:

The results of the survey show that Kazakh schools have just started to implement the basic STEM algorithms in secondary education, so the "new thinking" in this module should primarily relate to teachers retraining within M.Ed. program and PD training courses in the field of STEM education methodology and psychology.

The greatest interest of respondents to additional occupations and leisure centers are shown mainly in the following disciplines: Mathematics – 26,9%, Physics – 22,6%, Technology – 22,1%, Biology, Robotics, Design and 3D-modelling –19,2% on each, technical creativity (engineering) defines the importance of development of practical training programs for students in the above disciplines.

The analysis of the answers shows that the choice of disciplines by students is mainly related to the so-called «traditional» STEM-subjects (Math, Physics etc.), but not to the innovative STEM-subjects such as Robotics, Design and 3D modeling. This fact points on the absence of motivation by students in teaching innovative STEM-subjects, so the solution of this problem may be introduced in promotion of STEM-focused events like STEM-days, STEM-weeks or STEM-festivals aimed to increase motivation in teaching innovative STEM subjects and to highlight their importance.

Judging from questionnaire' analysis, universities should create STEM-focused curricula (master's degree programs). The curricula should be aimed to reach the main goals of the STEM-approach implementation, to increase the motivation of students in teaching STEM-related subjects and to provide educational organizations with competent and skilled HR in the STEM-field.

Survey of specifics of teaching STEM subjects in school, STEM teachers' PD needs and prospects for integrated STEM approach implementation in Kazakhstan (based on the questionnaire for secondary school teachers of STEM-disciplines)

The goal of the survey is to study the specifics of teaching STEM-disciplines (Chemistry, Physics, Biology, Geography, Technology, Mathematics, Computer Science) in schools, to identify the PD needs as well as STEM prospects in Kazakhstan. 306 teachers from 20 settlements, including the cities of Nur-Sultan, Shymkent, Ust-Kamenogorsk, Pavlodar, Uralsk, etc. participated in the survey. The Highest percentage of participation falls on the city of Shymkent – 52.3%.

Outputs of the survey:
Respondents of the survey note that the main factors that negatively affect the motivation and quality of students' training in STEM-disciplines are the lack of modern educational and methodological support and modern educational equipment, special educational/laboratory equipment as well as low speed Internet connection in educational organisations. Apart from the shortcomings in teaching methodology, respondents point to a weak level of professional competence in the subject matter, psychological, pedagogical and technological training of STEM teachers, the lack of effective interaction between teachers, educational organisations, industrial partners in the implementation of STEM-disciplines, as well as low teacher motivation.
In general, teachers show a significant interest in STEM education, and therefore, it is necessary to develop and implement more in-depth training courses and programs for in-service teachers to adapt to a new model of STEM-education within the integrated approach.

M.Ed. Curriculum and PD training courses to be developed within the project should focus on the following pedagogical approaches, teaching methods and techniques indicated by the respondents as providing high students' motivation and good learning outcomes within the STEM subjects: PBL, IBL, differentiated learning, research and laboratory studies.

Survey of specifics of teaching STEM-focused courses at supplementary education institutions, STEM PD needs and prospects for integrated STEM approach implementation in Kazakhstan (based on the questionnaire for STEM-teachers at supplementary education institutions)

The goal of the survey: to identify opportunities in joint activities in the field of STEM-education with universities and schools, study of the features of the implementation of additional General education programs and courses in the field of STEM-education (technical creativity, programming, design and 3D-modelling, robotics, etc.) in organisations of additional education of children and youth in Kazakhstan.152 teachers implementing additional General education programs and courses in the field of STEM-education participated in the survey.

Outputs of the survey:
The results of the survey show the need to expand the training program of STEM-education in 3 main areas: theoretical training, psychological adaptation of teachers to new interdisciplinary modules, practical development and implementation of integrated STEM modules. It seems certain that the regional STEM learning resource center intended to provide teachers with T&L materials, PD training/M.Ed. courses and relevant equipment should become the core element of the regional STEM ecosystem.

According to the survey results the respondents of this focus group are particularly interested in the following deliverables of the project “Integrated approach to STEM teachers training”: STEM PD training courses for teachers, best practices in STEM education and STEM ambassador programs.

Conclusions
To sum up, the project team considers that:
1) the interest and attitudes towards STEM-disciplines by students in Kazakhstan could be expressed with the following statements: STEM teaching in schools is fundamentally relevant to satisfy the majority of students. However, STEM teacher training programs to be developed should consider techniques and practices of motivating students as well as using ICT/lab equipment and STEM tools while promoting laboratory work, interdisciplinary projects and studying real-world cases within the framework of students’ career preferences.

2) specifics of teaching STEM subjects in school and STEM-focused courses at supplementary education institutions in Kazakhstan is shown in such a way: teachers show a significant interest in STEM education, and therefore, it is necessary to develop and implement more in-depth training courses and programs for in-service teachers to adapt to a new model of STEM-education within the integrated approach.

3) STEM teachers’ PD needs and prospects for integrated STEM approach implementation in Kazakhstan are as follows: M.Ed. Curriculum and PD training courses to be developed within the project should focus on the following pedagogical approaches, teaching methods and techniques indicated by the respondents as providing high students’ motivation and good learning outcomes within the STEM subjects: PBL, IBL, differentiated learning, research and laboratory studies. At the same time, it is necessary to develop STEM ambassador courses and carry out STEM

events like STEM days & weeks, STEM festivals in terms to overcome the negative trends of participation' absence in STEM-focused activities and to increase the role of integrated STEM-approach in the whole educational area.

The analytical data of the survey were used for developing learning outcomes of master programs

Development of master program. The program has been developed within the framework of the **European project Erasmus+ "Integrated Approach to STEM Teacher Training** with the participation of the University of Limerick (Ireland), the University of Helsinki (Finland), Linkoping University (Sweden).
The educational program has been developed in accordance with the state mandatory standard of postgraduate education of the Republic of Kazakhstan. Learning outcomes are formulated based on the guidelines of the European Credit Transfer and Accumulation System (ECTS).

Name of the programme: "Physics and computer science with the basics of STEM learning"

Number of ECTS credits for the programme: 120

Aim/purpose with the programme: Training of highly qualified competitive masters who meet modern principles of teaching in the field of STEM education, based on leadership and an integrative approach to teaching and research.

Learning outcomes for the programme.
1. Deeply understand modern trends in education, features of STEM - training for the development of functional literacy of students.
2.Effectively use psychological and pedagogical technologies in professional activities necessary for the training, development and education of students, including those with special educational needs
3.Conduct training sessions professionally, actively using STEM technology to develop students' life skills.
4.Integrate and apply science and engineering practices into teaching, learning materials and assessment, demonstrating skills in analysing, selecting and transforming information.
5.Reasonable to plan and manage projects at all stages of their life cycle, solving problems based on critical thinking, applying digital technologies and resources, using logical, systematic and sequential approaches
6.In cooperation with colleagues, plan and conduct research in the field of natural and pedagogical sciences to improve the practice of education, introducing the results of research into practical pedagogical activities.
7.Generate new ideas and solve professional problems, including interdisciplinary areas.

8. Critically determine the strategy of scientific, socio-pedagogical and communicative activities, making decisions and taking responsibility for the results.

Content of the programme

The curriculum content of the Master's degree is divided into six modules, which is done so according to the main focus of the program. The next types of activities are used in education: Lecture(L), Lecture with practice (LP), Practice(P), Seminar(S), Research seminar (RS), Laboratory work (LW).

Module 1: Module of Scientific and pedagogical training

It aims to provide a holistic overview of the history and philosophy of the development of science, problems and trends in higher education. The courses of this module are:

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Methodology module is aimed at examining various didactic strategies of pedagogy to foster the innovative engagement of diverse learners. The courses of this module are:

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- Methods and technologies of STEM education (5 ECTS, LP).

Module 3: Technology module

The Technology module is aimed at equipping future STEM teachers with conceptual knowledge of the STEM approach in education and digital skills to be employed for teaching different STEM subjects. The courses of this module are:

- Introduction to STEM (4 ECTS, LP, S);
- Concepts of modern natural science (4 ECTS; L, S)
- Online Educational Platforms (6 ECTS, L, S);
- Digital technologies in education (6 ECTS, L, S).
- Design and development of digital educational resources (6 ECTS, L, S).
- Pedagogical practice (4ECTS, P).

Module 4: Leadership module

Leadership module is aimed at fostering leadership skills to prepare future teachers for ongoing improvement of the learning environment. The courses of this module are:

- Management Psychology (4 ECTS, L,S);
- Leadership and teamwork (6 ECTS, L, S);

- Project management (6 ECTS, L, S);

Module 5: Physics of high technologies module

Physics of high technologies module is aimed at equipping future STEM teachers with methodological, organisational, and research skills to be employed for teaching different STEM subjects.

- Technologies for converting solar and thermal energy into electrical energy (6 ECTS, LP);
- Thermal radiation (6 ECTS, LP);
- Physical foundations of high technologies (7 ECTS, LP, S);
- Experimental physics (7 ECTS, LP)
- Intelligent robotic systems (7 ECTS, LP)
- Educational Robotics (7 ECTS, LP)
- Cloud technologies (7 ECTS, LP)
- Augmented reality (7 ECTS, LP)

Module 6: Research work and final attestation module:

Research module is aimed at enabling students to become informed consumers of research and to develop skills to prepare them to carry out action research in their schools and organisations. The content of this module is:

- Research work of a master student, including an internship and a master's thesis (24 ECTS, RS)
- Execution and defence of the master's thesis (12 ECTS, RS)

Creating a STEM center.

In 2021, a STEM center was opened at M. Auezov South Kazakhstan University. The aim of creating a STEM center is to provide training and consulting services for a wide range of stakeholders: teachers, students, non-formal teachers through training seminars and teaching materials online.

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In the STEM center, equipped with the necessary equipment for young researchers, students will learn to write programs, create websites and applications, design robots and master new technologies, using knowledge of the laws of physics, mathematics, chemistry, biology. Trainers trained within the framework of the project will conduct advanced training courses for teachers**.**

International Summer Online School "Modern Trends in STEM Education"

M. Auezov South Kazakhstan University held from July 27 to July 31, 2020 the International Summer Online School "Modern Trends in STEM Education" in the framework of the project "Integrated Approach to STEM Teacher Training" of the Erasmus + program for students of educational programs in the field of educational and natural sciences, engineering, technology and future STEM teachers.Within the framework of the summer school speakers from 7 HEI-s of the near and far abroad countries were invited, such as Linköping University(Sweden), University of Helsinki (Finland), Southern Federal University, Belgorod State University, A. I. Kant Baltic Federal University (Russia Federation) and L. N. Gumilyov Eurasian National University, M. Auezov South Kazakhstan University (Kazakhstan).

The online format of the school made it possible to attract more than **60** listeners for work of the school from two countries - Russia and Kazakhstan. Among the participants were university HEI teachers, school teachers, as well as potential applicants for a master's degree in STEM pedagogy.

Dissemination of the project results

In order to disseminate the results of the project, 4 STEM weeks and 8 STEM days were held at M.Auezov SKU. As part of these events, participants shared their experience in the field of STEM education. During the STEM weeks and STEM days, the speakers introduced the audience to global trends in education, inquiry-based learning and project-based learning methods; master students of the educational program presented their projects in the following areas: 1) the use of simulators of laboratory work related to the topic under study; 2) designing laboratory work with your own hands on the topic under study; 3) creation of simple models working on the principles of physics; 4) creation of simple robots.

Chapter 7: STEM best practices in Kazakhstan: S. Amanzholov East Kazakhstan University

Saltanat Anikanova & Ainagul Kadyrova, S. Amanzholov East Kazakhstan University, Kazakhstan

The Erasmus+ project "An integrated approach to the training of STEM teachers" at S. Amanzholov East Kazakhstan University began its work in 2019.

The main goal of the project is to train scientific and pedagogical personnel capable of implementing technology-oriented IT projects based on an integrative approach

Project objectives:

1) Development of master's degree programs for STEM teachers based on an integrative approach (for primary school teachers and STEM teachers for secondary schools and STEM teachers at universities);

2) Creation of regional STEM resource centres providing consulting and training services;

3) Teaching teachers new pedagogical skills, creating a STEAM-learning learning environment.

Impact at the institutional level:

Within the framework of the project, the S.Amanzholov EKU developed the educational program 7M01513- "STEM education" in the direction of "Training of teachers of natural sciences" and in the 2020-2021 academic year, admission to this educational program took place.

Under this program, undergraduates are trained at the expense of state grants from the Ministry of Education and Science of the Republic of Kazakhstan, which, in our opinion, indicates the further stability of the OP.

A STEM center was opened at the Higher School of IT and Natural Sciences, which has equipment and computer equipment for conducting classes.

The project was implemented in cooperation with other educational organisations. For example, interviews were conducted with teachers about the introduction of STEM education in schools, and an online survey was conducted among school teachers in the Ust-Kamenogorsk and East Kazakhstan region.

Their opinions were taken into account when developing the content of the disciplines of the Master's degree program.

During the survey, teachers suggested testing pedagogical techniques and STEM-learning technologies on the basis of the discipline "Robotics".

There is a training laboratory "Robolabs" at the S.Amanzholov VCU, which has thematic designers on mechanics, electricity

Impact at the international level.

A network of partner universities of the project participants has been created to exchange experience and best practices in the field of STEM education on the territory of the Republic of Kazakhstan and with the countries of the Russian Federation and the EU.

S.Amanzholov EKU took part in the webinars held by the project coordinators. Issues related to the implementation of measures according to the plan for the admission of students for the 2020-2021 academic year were discussed. One of the main issues is the development of an educational program and modules of disciplines.

In the online mode, with the participation of partner universities, using the Google document, the structure of the master's degree educational program was compiled, in which conditions for academic mobility of students were created.

The development of the STEM educational program based on international educational standards contributes to the development of the education system of the Republic of Kazakhstan and brings it to the international level.

The Higher School of IT and Natural Sciences has a dissertation council, the Department of Computer Modeling and Information Technology has a doctoral program in the pedagogical direction. It is possible to defend dissertations in the dissertation councils of partner universities of the project.

The Department of Computer Modeling and Information Technology held discussions and pre-examination of students' theses and master's theses on STEM-learning topics.

All partner universities of the project were involved in the development of the Master's degree program for the training of teachers in the direction of STEM.

For example, on June 24-26, 2019, a meeting was held with foreign partner universities within the framework of the Erasmus+ program on the project "Integrated Approach to STEM Teacher Training" at the University of Limerick (Republic of Ireland). The purpose of the meeting is to study the best practices and methodologies

of the EU in the development of a unique master's program for STEM teacher training based on an innovative integrated approach in accordance with the Bologna Rules

https://enu.kz/ru/info/novosti-enu/57535/?sphrase_id=3831134

The 3rd semester was chosen for academic mobility training, so the content of the educational program of this semester contains general modules of disciplines, and the first and second semesters contain university disciplines. Due to the pandemic, there was no academic mobility of students.

The developed educational programs have been approved by the European Commission.

On 04/29/2020, a round table on the compilation of the OP was held with colleagues from partner universities:

- L.N. Gumilyov Eurasian National University (ENU, Republic of Kazakhstan);

- M.O. Auezov South Kazakhstan University (SKSU, Republic of Kazakhstan);

- S. Amanzholov East Kazakhstan University (EKSU, Republic of Kazakhstan);

- Southern Federal University (SFU, Russia);

- Immanuel Kant Baltic Federal University (I. Kant BFU, Russia)

- Belgorod State National Research University (BelSU, Russia).

The structure of the educational program was compiled in Google Drive. OP "7M01513-STEM education" has 120 ECTS, of which 104 ECTS (87%) have updated disciplines taking into account practice (52 credits of updated disciplines, 52 - various types of practices), 16 ECTS (13%) have not updated disciplines.

Name of discipline	Total ECTS	With practice	Without practice
Not updated disciplines	16	13%	24%

Updated and new disciplines	52	87%	76%
Research practice	12		
Research work of the master student	24		
Registration and defense of the master's thesis	12		
Pedagogical practice	4		
	120	100%	100%

The title of the program: «7M01513–STEM -Education»

Module name and code	Name and code of discipline	Number of ECTS credits	Semester
General scientific	Foreign language (professional)	5	1
	Information and educational environment for STEM- learning	5	1
Methodological approaches to teaching	Digitalization of education and learning problems	5	1

	Practice of academic writing and research methodology	5	1
	Diagnostics of Stem learning outcomes	5	1
Technologies and integration	Network pedagogical technologies in the educational process	5	2
	Integrated approach to computer science education	5	2
	Education Quality Monitoring Web-technologies	5	2
	SMART-Technologies in Education	5	2
	Polylingual teaching informatics	5	2
	STEM- teaching of natural science disciplines	5	2
Applied aspects	Big data technologies in education	5	2

	Educational Data Mining	5	2
Teaching methods for integrative STEM for natural Sciences	Protection of information resources in education	5	3
	Academic writing and research integrity	5	3
	Cloud technologies	5	3
	Digitalization of education	5	3
	Parallel Computing	5	3

Every year, the curriculum content is updated by 30%.

Catalogue of elective courses of the educational program "7M01513– STEM education" for students of the 2020 admission year. For example, we give an example of the content of this subject from the catalogue of elective disciplines:

Diagnostics of STEM -learning outcomes

The purpose of the discipline is to introduce students to the process of generalising the diagnosis of STEM learning results

The content of the discipline is aimed at studying the forms of control, reflection in accordance with the Bloom taxonomy of mental activity in STEM-learning, methods of pedagogical diagnostics, formative and summative assessment in STEM-learning, testing methods, algorithms for statistical processing of test results; drawing up evaluation criteria in accordance with the descriptors of the compiled tasks, the use of statistical methods in analysing the results of control and monitoring of the educational process in STEM-learning.

As a result of studying the discipline, the student will: 1) to systematise the principles of statistical processing of test results; the main methods and algorithms of statistical processing,

2) to apply statistical methods and algorithms in solving problems of analysing results in STEM-learning; 3) to design training tasks for STEM training on the formation of competencies in accordance with the Bloom taxonomy, 4) to apply formative assessment, interactive and differentiated learning based on electronic and mobile technologies, 5) to develop procedures for managing the quality of the educational process related to the creation of diagnostic programs, monitoring the quality of learning in STEM-learning, 6) to create electronic teaching materials.

Post Requisites: SMART-Technologies in Education, Education Quality Monitoring Web-technologies

Integrated approach to computer science education

The goal is to train a specialist who is able to define and justify a set of didactic conditions for the implementation of integrated learning using information technologies.

The discipline is aimed at studying the directions of digital transformation in schools and universities. The characteristics of the digital educational environment are given, the model of "digital learning" is defined, the conditions for improving the effectiveness of educational activities, the risks of digitalization, the forms of introducing online courses into the educational process are considered, the complex of competencies is defined (self-organization, remote motivation management, work with granular educational content)

As a result of studying the discipline, the student will: 1) to develop procedures for managing the quality of the educational process on an integrative basis, 2) to apply a rational construction of the educational process on an integrative basis, 3) to design training tasks in computer science based on the integration of content with humanities and natural science disciplines, 4) to apply formative assessment, interactive and differentiated learning based on electronic and mobile technologies, 5) to work in the conditions of the pedagogical community of educational institutions; tolerate social, cultural and personal differences.

Prerequisites: Higher School Pedagogy, Digitalization of education and problems of learning

STEM- teaching of natural science disciplinesTEM

The goal is to train a competent specialist who is able to navigate a wide range of modern information technologies in education, as well as using the capabilities of the interdisciplinary integrated STEM approach in the implementation of holistic, practice-oriented teaching of natural science disciplines.

The discipline prepares students to acquire knowledge and skills in the field of STEM-technologies of teaching natural science disciplines, including the study of the idea of interdisciplinary connections, practical orientation and activity component.

As a result of mastering this discipline, the student will: 1) to integrate methods, knowledge and tools of various disciplines in solving practical and project tasks, 2) to apply the interdisciplinary integrated approach of STEM in the implementation of the teaching of natural science disciplines, 3) to design training tasks on an activity-based basis - through experimentation, research, design, construction, programming 4) to develop procedures for managing the quality of the educational process related to the creation of diagnostic programs, monitoring the quality of training 5) to work in the conditions of the pedagogical community of educational institutions; tolerate social, cultural and personal differences. 6) to perform system modelling; describe processes in applied tasks in STEM-learning

Prerequisites: Higher School Pedagogy, Practice of academic writing and research methodology, Digitalization of education and problems of learning,

Post Requisites: Teaching practice (continuous), Cloud computing technologies in e-learning, Protection of information resources in education

At «7M01513-STEM Education» undergraduates' study in a multilingual group. In the first year, the discipline "STEM- teaching of natural sciences" is conducted in English, the rest, at the choice of undergraduates, are conducted in Russian, Kazakh.

Directors and teachers of educational institutions of the region take part in the preparation of the educational program. Such cooperation between the department and employers showed the absence of formalism in personnel training. Employers propose to make adjustments to the educational program so that undergraduates master scientific and subject-specialised competencies that promote mobility and sustainability in the labour market.

Employers proposed to include in the content of the educational program the development of educational and methodological material on the subject in accordance with the technology of integrated subject-language learning, diagnostics of the effectiveness of STEM / STREM education, the study of the organisation of technology-oriented projects in computer science.

The department received from employers reviews of the educational program from the Altai State University (city Barnaul, Russian Federation, Associate Professor Ponkina E.V.), Nazarbayev Intellectual School of the city Ust-Kamenogorsk (Sapuanov B.Zh.),

the Regional Center for New Technologies in Education of the region (Sagandykova Zh.), the Kazakh National Pedagogical University named after Abai, of city Almaty (Professor Oshanova N.T.)

The subject of study of undergraduates are: 1) the educational process in the unity of its value and target orientations, content, methods and results; 2) research, innovation, information and analytical activities in the field of computer science, applied mathematics, pedagogy, methods of teaching computer science and robotics

The uniqueness of the educational program: The training program gives students an idea about the applied tasks of pedagogical management, about the forms and technological methods of managing pedagogical systems that are aimed at solving the educational and methodological tasks of organising STEM / STREM training

STEM –training of undergraduates' forms students':

1. Integrated learning techniques aimed at the development of technology-oriented IT projects based on the application of mathematics, physics, robotics, information technology

2. Binary lesson techniques in the process of studying the interrelated material of two or more disciplines;

3. Be able to organise interactive learning with feedback based on e-learning and mobile learning technologies,

4. Be able to create digital didactic materials for the information educational environment

5. To design the educational process according to the developed criteria for evaluating educational tasks, with a focus on developing the levels of thinking skills according to Bloom's taxonomy; taking into account the methods of formative assessment and feedback

6. Apply methods of differentiated assessment of training in integrated disciplines; criteria and mechanisms of the cretirial assessment system

7. Techniques for implementing professional secure networking with colleagues to improve educational practice

8 Develop quality management processes for educational activities related to the creation and use of inclusive learning software for marginalised groups (ethnic and national minorities, residents of rural or remote areas, girls and women, etc.).;

5 undergraduates study in the 2nd year, and 2 undergraduates study in the first year. The recruitment of students is planned at the expense of state grants, an order to the Ministry of Education and Science of the Republic of Kazakhstan.

March 10, 2020. online participation of teachers Kadyrova A., Tolykbayeva M. in the Republican seminar "Teaching robotics in offline and online format" on the basis of "SANA Intellectual Center Nur-Sultan, 2 certificates were received.

On April 19, 2021, the STEM Center was opened in a mixed format (auditorium No. 210 of the academic building No. 7, 148 Shakarim Ave., Ust–Kamenogorsk). Trainings are held in the STEM centre, a team meeting is held weekly (Wednesday, 15.00).

The project team members presented information about STEM education on posters, information materials on STEM education, booklets of the Master's degree program, certificates of participation of teachers in various conferences, seminars and festivals, competitions. The participation of students of the department in various conferences, STEM competitions is also presented in certificates.

The project participants were familiarised with information about the Erasmus+ rules, the application competition, the selection procedure and priorities, and also gave practical advice to those wishing to participate in Erasmus+ events (Actions "Increasing the potential of Higher Education", "Academic Mobility", "Erasmus Mundus Development - Erasmus Mundus Project Events"). The program of the Information Day is published on the website www.erasmusplus .kz

Awareness-raising activities on STEM learning are carried out constantly.

Registered participants – 200, Offline participants – 150, schoolchildren – 15, undergraduates - 28, students - 16, speakers - 24

November 24, 2020 – online section organisation of the section at the international scientific conference "Amanzholov readings 2020" VKU, Ust-Kamenogorsk, 42 reports of teachers of rural and urban schools)

March 26, 2021 online seminar "Integrative approach to STEM education" for teachers of the region, 44 certificates were developed and sent out (VCU, Ust-Kamenogorsk, East Kazakhstan region)

On April 19, 2021, the opening of the STEM centre (auditorium No. 210 of the academic building No. 7, 148 Shakarim Ave.) was held in a mixed format, which was attended by KGKP "Station of Young Technicians"), secondary school teachers №15, №22, №25, №4 G. Ust-Kamenogorsk. Thematic stands and equipment received from partner universities are placed in the auditorium.

June 30-July 2, 2021, online participation of undergraduates of the OP "7M01501-Informatics" in the summer school of the partner university under the project of the I.Kant Baltic University (Kaliningrad, Russia): KSU "Secondary School No. 45", KSU "Secondary School No. 4", KSU "Secondary School No. 22", KSU "Secondary school No. 34", KSU "Secondary school No. 26", KSU "Srednyaya school No. 44"

August - September 2021 - participation in the seminar of the development centre "DALA Bala" in the STEMLab office

September 23-25, 2021, online conference "Special educational needs of students in the system of continuing education" Section No. 2 "STE(A)M-education and professional training of a teacher in the context of global technological challenges" Organised by Southern Federal University (Rostov-on-Don).

October 13-15, 2021 onlan -participation in the "STEM Ambassador training" with the participation of professors Maija Aksela (Director of LUMA Centre Helsinki), planner Oona Kiviluoto (LUMA Centre Finland), chemistry and mathematics teacher Reija Pesonen (University of Helsinki), specialist in scientific education Topias Ikävalko (University of Helsinki). Organizer Southern Federal University (city Rostov-on-Don).

November 03, 2021, online participation in the Republican seminar "STEM education - the basis for the development of students' research skills", organised by the SANA Intellectual Center in Nur-Sultan, Kazakhstan. (Teachers Kadyrova A.S., Dzhaksalykova A., master's student OP 7M01513-"STEM education". Abdikadyrova U., received certificates.

November 26-27, 2021 online participation in section No. 3 at the International Scientific Conference "Amanzholov Readings 2021"

From December 2021 - February 2022 - Joint training courses for teachers. Partner universities of the NAO South Kazakhstan University named after M. Auezov (Shymkent, RK), Southern Federal University (Rostov-on-Don, RF), NRU "BelSU", Belgrade, RF, Baltic University named after I.Kant, Kaliningrad, RF, ENU named after L.N. Gumilev participated (Nur-Sultan, RK).

February 22, 2022 – onlany-conducting a teacher training course. The report presented the developed MOOC - Electronic training course for teachers "Robotics on the Arduino platform" in the implementation of STEM training (the authors are teachers Dzhaksalykova A., Sarbasova K., Tolykbaeva M.).

On March 29, 2022, the seminar of L.N. Gumilyov ENU was dedicated to raising awareness about the preparation of masters within the framework of the project "An integrated approach to the training of STEM teachers" of the Erasmus+ program. The seminar was attended by the teaching staff - participants of the project "An integrated approach to the training of STEM teachers" of L.N. Gumilev ENU, S. Amanzholov East Kazakhstan University and M.O. Auezov South Kazakhstan University.

The results of the work on informing the public about the work of the project were discussed and plans for further work were announced. Instagram Facebook and YouTube, Serik M the project coordinator asked to talk about the activities of the project participants on the pages of republican newspapers and magazines, social networks Instagram, Facebook and YouTube, and introduced career guidance work on STEM education.

Coordinator, Vice-rector of the University of Higher Education named after S.Amanzholov, I.V. Rovnyakova spoke about the work on the dissemination of STEM education in the East Kazakhstan region

April 28 and May 04, 2022 - Online joint final seminar of the teacher training course organized by L.N. Gumilyov ENU (Head of the Department Kadyrova A., Dean Adikanova S., teachers Dzhaksalykova A., Tolykbaeva M., 14 undergraduates

20.06.2022-30.06.2022, a festival and a summer school for the training of electronic teachers in the STEM direction were held within the framework of the Erasmus+ program.

5 undergraduates from Ust-Kamenogorsk came to Nur-Sultan for offline training and exchange of experience https://enu.kz/ru/info/novosti-enu/66741/?sphrase_id=3787609 .

The summer school program can be found here STEM Festival & Summer school Program

On October 04-11, 2022, senior lecturer of the Department Kaidarova M. and undergraduate student Agyzam D. took part in the STEM coordination meeting organised by Professor Janerik Lundquist (Linkoping University), which is taking place at Ibn Khaldun University of Istanbul (Turkey).

On October 21, 2022, the organisation and holding of the meeting of section No. 3 of the International Scientific and Practical Conference "Uvaliev readings 2022" of the NAO "VKU named after S.Amanzholov", out of 78 planned reports of the section, 12 reports on STEM-direction, 5 articles were printed.

November 08, 2022 - the final seminar "STEM education at school: from theory to practice". The partner universities of the project "Integrated Approach to STEM Teacher Training" received invitations and participated in it: L.N. Gumilyov ENU, SKU of name M.Auezov

8 reports on STEM learning experience.

November 16, 2022 participation in the Republican contest Skills UP- Hakaton-2022, UN Development Program in Kazakhstan (Kazakhstan, city Ust-Kamenogorsk,

students of educational program «6B06103 Computer mechatronics», heads lecturer Kopzhasarov B., Dzhakishev A.

November 20, 2022 participation in the international competition of research papers for students and students of educational institutions in the field of technical and physico-mathematical sciences, 3rd place. Place of realisation: Russian Federation, city Nizhny Novgorod, NOO "Professional Science", students Kusainov G. (educational program “6B06103 Computer mechatronics"), Bekkaliev R., (educational program "6B06103 Computer mechatronics") on the topic "Making figurines using 3D printing technologies", head lecturer Kopzhasarov B.

November 26-27, 2022 - undergraduates Agyzam D., Amangeldin A., Dean Adikanova S., senior lecturer Kaidarova M., on the International project "Integrated approach to STEM teacher training- The directions of the "Erasmus + program", went to the Festival "STEM & Makers Fest / Expo in Cappadocia (Turkey), prepared by the University (Nevsehir) Haji Bektash Veli, which was attended by universities in Turkey (the STEM & Maker Laboratory of Hacettepe University, Haji Bektash Veli University, Cappadocia Technopark and the Ministry of Education), Sweden, Ireland, Finland and Kazakhstan (M.Auezov SKU, S.Amanzholov VCU).

The festival presents a parking sensor device made with the help of an ultrasonic sensor for a car (master's student of 2 years of training Amangeldin A. Many motorists know the parking radar, as it is an active driver assistance system for parking, detecting an urn, a high curb or an abandoned cart. Parktronic easily notices these obstacles and warns the driver about them in a timely manner.

The second project at the festival is a complex with the help of solar and wind energy, QR codes for rewards sorts garbage, a 2-year undergraduate student Agyzam D. A 3D model of a garbage sorting complex determines the type of waste due to the work of sensors, as well as a neural network written in the Python programming language. The user brings an object with a colour tag (plastic, paper, metal and other waste), sensors recognize the colour of the material, and the conveyor motors open the appropriate tank for this type of garbage. The recognized waste is transferred from the tanks to a special compartment of the container. Thus, each type of waste ends up in its own compartment of the container.

Printed and assembled in the Robolab laboratory of the department. Containers with food waste will be made with a cooled ventilation system to eliminate unpleasant odors. The complex will work using the energy of the sun, wind, rain.

November 2022 - an application was submitted for a Competition for grant funding for scientific and (or) scientific and technical projects for 2023-2025 on the topic "Formation of digital skills of students using ontological engineering and STEAM

approach" (71232800 tenge). The project manager is Adikanova S., the group consists of Bazarova M., Kadyrova A.S., Dzhaksalykova A.

December 17-19, 2022 – holding of the winter school "STEM- design for robotics and 3D printing" (the format of classes is mixed). Venue – Shakarima Ave., academic building No. 7, computer science teaching room, STEM centre, Robolab laboratory.

The event was attended by teachers and students of KSU "Secondary school No. 35", KSU "Secondary school No. 30", KSU "Secondary school No. 49" of city Ust-Kamenogorsk, Nazarbayev intellectual school of Ust-Kamenogorsk, KSU "Profile school", KGGP "Station of young technicians", KSU "Kazakh secondary A.Bokey school" Glubokovsky district, KSU "D.Dzhambul Complex School" of Tarbagatai district, KSU "Kurchum Gymnasium No. 3" of Kurchum district, teachers of NAO "Zhetysu University named after I.Zhansugurov", KSU "Higher IT College", teachers from partner universities of NAO "ENU named afterL.N. Gumilyova, NAO "YUKU named of M.Auezov".

Thus, the project participants of the Department of Computer Modeling and Information Technology created a video film on the project activities; compiled a career atlas in Kazakh, English;

In June 2022, the educational program "7M01513 "STEM-education" passed the primary accreditation of the IAAR agency on the indicators of assessing the quality of educational programs for compliance with the standards of specialised accreditation for 5 years.

Classes in the disciplines "Fundamentals of Robotics", "Mechatronics and Electronics", "Robot control programming" were organised with students of the bachelor's programs "6B01501-Computer Science", "6B06102-Information Systems", "6B06103-Computer mechatronics", classes in the disciplines "Information and educational environment of STEM learning", "STEM- teaching of natural science disciplines", "Digitalization of education and learning problems" with undergraduates of the program "7M01513-STEM education" on the basis of the Robolabs laboratory (academic building No. 7, auditorium 216), STEM center (academic building No. 7, auditorium 210),

April 2022 - a review of 12 articles of undergraduates at the meeting of the department (Protocol No. 8) on the STEM direction of students of OP 7M01501-Informatics, OP 7M01513 "STEM education" was conducted.

From January 3 to 5, 2023, planner of the International Scientific Project "Integrated Approach to STEM Teacher Training" within the ERASMUS+ program with 4 European universities: Linköping University (Sweden), University of Helsinki (Finland), University of Limerick (Ireland) and Hacettepe University (Turkey), Professor Oona Kiviluoto (Oona Kiviluoto) (LUMA Centre Finland, University of Helsinki, Finland)

visited S.Amanzholov East Kazakhstan University in order to inspect the material, classroom fund of educational laboratories and discuss the results of its three-year project implementation.

The department continues its career guidance work. Booklets for applicants were made. *Instagram, Facebook* and informing interested parties about changes in the OP is implemented in social networks Instagram, Facebook.

Links:*1)* *https://www.instagram.com/vkgu_kmiit_univer/?target_user_id=6771951023&utm_source=instagram&utm_medium=email&utm_campaign=follower_activity_email&click_source=footer_profile&__bp=1*

2) *https://m.facebook.com/story.php?story_fbid=pfbid0Mu37yrxtYzhbahPwydZCKPybQxdfGWQQ9ejf8i5ML6keUahbiB4RkfbwRnTiKGyrl&id=100010672355726*

Link to the Department of Computer Modeling and Information Technology

https://fenit.vku.edu.kz/ru/page/o-kafedre-kmiit.htm

Link to the educational program "STEM education" https://www.vku.edu.kz/en/page/Magistracy.html

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The Department of Computer Modeling and Information Technology held discussions and pre-defence of students' theses and master's theses on STEM-learning topics.

The following resources have been developed

1) 3D model of the intelligent complex of the garbage sorter 3D. The author is a - Master's student Agyzam D.

2) A parking sensor device manufactured using an ultrasonic sensor for a car. Author: Amangeldin A. - Master's student

3) Automated solar panel.Author: Khausulkhan E.R. /9th grade student of KSU "Secondary school No. 15" of Ust-Kamenogorsk, head of Agyzam D.

4) Digitizer design. Author: Kopzhasarov B.K., lecturer of the department

5) STEM- project of using a sound sensor Author: Imasheva I. graduate student 7M01513 "STEM education"

6) Using a 3D printer as a visual mechatronics tool. Author Kusainov G. student of OP "6B06103 Computer mechatronics"

7) Angle detection sensor and data interpretation Author: Tortaul N., student of OP "6B06103- Computer mechatronics.

The following publications are planned:

1) A STEM computer science training workshop: a textbook –Authors: Bazarova M., Adikanova S., Kpozhasarov B.T., Kadyrova A.S., Dzhaksadykova A. in Russian, the deadline is March 2023.
2) 3D Printing STEM Training Workshop: electronic training course on the Stepik platform – Authors: Bazarova M., Adikanova S., Kopzhasarov B.T., Kadyrova A.S., Dzhaksadykova A. in Kazakh /English, term March 2023.

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