Euro-Asia Collaboration for Enhancing STEM Education

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ABSTRACT
EASTEM is a capacity-building project funded by Erasmus+ with the aim of improving employability of STEM (Science, Technology, Engineering and Mathematics) graduates from partner universities by ensuring students acquire skills needed in the workplace. EASTEM uses approaches from student-centred STEM education to develop the competence of lecturers and bridge the gap between industry and universities. Over the course of three full years (2019-2022) the project brought together ten universities from Asia and three universities from Europe to work together on improving STEM education, creating a platform for partner universities to exchange best practices on student-centred STEM education. Two associate partners, the Ministry of Education and Training of Vietnam and Vietnam Electronics Industries Association are supporting EASTEM activities.

KEYWORDS
STEM education, STEM centres, academia and industry collaboration, student-centred approach, computational thinking

1. INTRODUCTION
Universities across the world are seeking to form global partnerships and fostering relationships with other institutions.

EASTEM project (http://eastemproject.eu/) is focused on advances in the quality of teaching. Increased connections between universities, corporate partners and schools brought about by the EASTEM project are set to improve the employability of graduates, fulfilling industry needs of the workforce in Indonesia, Thailand and Vietnam. The recent shift to online teaching and learning in all our partner universities have further increased the need to teach in ways that engage students. Improving the competence of teachers and the quality of higher education in STEM to ensure that graduates can make the best of their abilities are considered crucial measures for industrial competitiveness in partner countries.

There is an increase in demand for skilled professionals within the STEM field across the globe, and a high number of STEM workers are reaching retirement age, adding further pressure to an already skill-short area. Thus, a high quality STEM education is seen as a critical success factor for Asian countries in light of the fourth industrial revolution. Development of professional skills such as teamwork, communication and leadership skills, quality of education in relation to the demands of the job market, and employability are skills that we can learn by collaborating and cooperating.

The project partners are drivers for change in educational approaches in their local and national context. Still the majority of teaching is based on traditional methods rather than meeting today's need of the students. This is in spite of government efforts. For example, in Vietnam the Ministry of Education and Training has identified STEM education as a key factor for development. In Indonesia, all of higher education curriculum must refer to Kerangka Kualifikasi Nasional Indonesia (Indonesia National Qualification Framework), focusing in part on competence development. As part of the Thailand 4.0 Policy of the Thai government and the strategy of the Ministry of Education, Thailand is hoping to develop a holistic strategy to prepare teachers and school leaders to deliver education reform, with a strong emphasis on improving teachers' skills to make the best use of technology in the classroom.

The project partner universities have established policies and strategies for moving their institutions forward into the next decade, with a strategy to proactively support the needs of the communities and society, to produce quality graduates who have a mind to serve the society and to develop research and create innovations for the development of economy, society and local security. Nevertheless, the institutions involved in EASTEM is at the forefront of this movement, they have expressed a need for the activities planned in this project. In spite of the focus on development of professional skills development for employability in recent years nationally, regionally and locally, the penetration rate remains low, particularly in STEM education.

With the knowledge exchanged through the partnership, each partner's expertise and experiences from different contexts can synergistically enrich each other, and will in turn subsequently benefit the members within this resulting strengthened network. This includes developing strategies for enhancing each university's own STEM education system, to establish a platform for networking on STEM education, and to safeguard the pitfalls of education in rapid changes of science and technology.

EASTEM structure and activities are built on a European model for how learning and teaching in the STEM area should be enhanced. These strategies can (and should) be contrasted to formalized "teaching methods", where certain predefined protocol for how the teaching should take place

is to be followed. Such formalized teaching methods lack the flexibility to follow the development of the discipline, the students, the students' future employers, and the needs of these entities, and are difficult to adapt to new student groups and/or new environments. These strategies should be adapted to the local cultural, social, economic and disciplinary environment. By doing that, they turn out to be powerful tools for enhancing the quality of STEM education.

There have been several initiatives focused on skills development and employability. EASTEM, described in this paper, differentiates itself on several points, grounded in a European model for enhancing STEM education. Firstly, EASTEM focus on approaches for making education more focused on the students and their needs, not through specific teaching methods. Secondly, the main attention is to integrated STEM education. Thirdly, in order to capitalize on previous and current initiatives we address student competence development on three levels in order to vitalize the student-centred STEM education. Fourthly, EASTEM lays the organizational foundation for a STEM Education network, providing visibility to initiatives within the field. Finally, in being rooted in staff development in two phases, the Asian universities conduct and establish their own staff development adaptation to local contexts.

2. COLLABORATION AND EXCHANGE OF GOOD PRACTICES

Working together in the EASTEM project, we are currently a part of the ongoing national and European reform of STEM in schools and universities. The motivation is to move from subject-oriented STEM to transdisciplinary and project-oriented STEM (Pears et al, 2019). The political goal is to increase the motivation of students in STEM and increase the number and diversity of students interested in STEM university subjects and professional STEM and engineering careers. The educational goal is to focus on transdisciplinary aspects and promote research-based education (Cook, Bush, 2018). At the same time, a number of international, regional and national research-based initiatives are underway to improve university and high school STEM education, focusing on student skills development and related aspects.

Synergistic learning combining Computational Thinking (CT) and STEM has proven to be an effective method for advancing learning and understanding in a number of STEM domains and simultaneously helping students develop important computer science concepts and practices (Park, Green, 2019).

Many computational environments and tools have been developed to promote CT competencies in STEM education. The way scientists and engineers approach problems is very similar to CT methodology: Identify problems and do research; Decompose the problem; Design the algorithm or create plan; Analyse results; Debug and modify, etc. (Palts, Pedaste, 2020).

Educators are often confused about CT and STEM and have difficulties to see the link. However, CT is a way of solving problems and can be integrated with various disciplines. Especially STEM contexts are very suitable for this. CT skills incorporate analytical thinking, engineering thinking, and scientific thinking. Thus, they could be positioned as a kind of universal skill for the modern student, and this is especially true for STEM education.

Besides critical thinking, creativity, communication and collaboration, CT can be seen as an important part of 21st century learning. The importance of CT is still underestimated in education. CT is a set of problem-solving methods that involve expressing problems and their solutions in ways a computer could execute (Denning, Tedre, 2019). Modern computation tools are changing the way science and mathematics are practiced. CT encompasses a wide range of mental processes, which are considered necessary supplies for the 21st-century children.

The aim of EASTEM project is to provide a European-Asian insight on student-centred STEM education research practice. It is based on a collection of best practices, case studies, analytical reviews, theoretical contributions focused on approaches to students' skills development and university-industry collaborative practices as related to university STEM education. The motivation is as follows. A look at the university STEM in terms of institutional development, focusing on: (a) country-specific STEM results for a range of unique experiences and best practices; (b) a look at collaborative practices and outcomes associated with global and international STEM activities. Specific topics could include: educational policies and managerial approaches to university STEM development and research; research on curriculum development and integration focusing on students' STEM professional competencies; Euro-Asian University and university-industry collaboration in research and best practices as related to university STEM. The project activities and outcomes are organized in three main strands.

2.1. Train lecturers in student-centred competence development

Partners developed trainings in student-centred STEM education approaches with the help of Uppsala University, Sweden. In the first phase, a number of lecturers from Asian partner institutions participated in a course in student-centred competence development. Then they set up a pilot course where students solve problems from local industries and communities in international teams at the different partner institutions. In the second phase, lecturers trained in the first phase conducted staff development sessions for other lecturers both within and outside of their institutions. At some occasions this was made for lecturers at the local institutions, but at some institutions those courses were also regional or national

In conclusion, the European and Asian partners have jointly developed and implemented student-centred STEM education staff trainings at the Asian partner institutions. At the same, a quality revision of the Asian partners teaching of STEM is taking place.

During the pilot course, the course participants (lecturers) taught modules for students applying their new ideas. In this way, the pilot module served as a test bed at the same time

as it is an occasion for the lectures to apply student-centred teaching approaches. Lecturers who have participated in the Training of Trainers courses are now applying SCL approaches that we have learnt in regular teaching with students. A particular focus has been on attitudes, both of the staff towards their new roles and the learners towards being in control of their own learning.

2.2. Establish STEM education centres

Vilnius University, Lithuania is supporting lecturers, deans and administrative staff at Asian partner universities to establish, staff and run STEM education centres to ensure the sustainability and increase the visibility of student-centred STEM activities. These centres should anchor STEM activities firmly within the university structure and serve as focal points for each university's STEM initiatives. By engaging both university students and external partners such as local high schools in centre activities, the centres have the potential to develop into hubs for STEM education and learning in each city or region. The establishment centre for excellence in STEM education is based on each partner university sharing of current status and good case practices.

The establishing of the Centre for Excellence in STEM Education allows:

- to improve study programmes quality through integrated style of study and to modernize the curricula of study programmes by including innovative learning and teaching tools;
- to engage students with STEM disciplines and to allow students to get acquainted with different STEM disciplines;
- to strengthen the link between academic environment (university) and work life, to develop competences needed for the job market;
- to develop the students' and teachers' soft skills;
- strengthen partnerships between university-industry-school;

Preparation of the feasibility study based on each partner's needs and best practices in STEM Centres. Mapping STEM Education centre conceptions in each partner's institution: preparation of the guidelines, recommendations, strategical plan of STEM centre establishment. Implementation part consists of preparation of training material, developing training modules, innovative methodological tools and pilot implementation:

1. Staff development in STEM Education Centre Management;
2. Staff development for Centre activities coordinators (university lecturers, researchers, who organize and implement activities in centre);
3. Launch of STEM centres (in each Partner University);
4. Piloting the STEM centres platform:
    - Activities (at university level);
    - Lecturers: 1) study and research organization for students; 2) consultation, expertise, research of educational process; 3) preparation of methodological material and tools for teachers;
    - University students' involvement in centre activities integrative modules, research, practice supervised by lecturers;
    - Activities (at the K-12 level);
    - School teachers training;
    - School students: formal and non-formal education activities in STEM centre;
5. Evaluation of launched centres activities;
6. Centres for Excellence in STEM Education consortium establishment.

An interdisciplinary platform for STEM education at universities provides sustainability for the project network, activities, increasing visibility of student-centred educational approaches and research in STEM education (https://www.fsf.vu.lt/en/eastem-centres-platform).

2.3. Facilitate industry engagement and competence integration into STEM educational programmes

New skills are required in the era of the Fourth Industrial Revolution and recognizing the importance of competence development for students, institutions are to facilitate education focused on students' needs but also offer STEM programmes that better align with labor market needs. Based on major accreditation requirements in the six partner countries, several University-Industry collaboration formats were categorized in themes (Rouvrais et al, 2020). They lay the foundation of a structured relationship model for STEM universities, which now permits to build on good case practices from all partner institutions. It thus contributes to advancing STEM-educational frameworks for curriculum guidelines aligned with skills for industry.

Going beyond concerns and models of an EASTEM educational framework, incl. curriculum development, SCL, industry collaboration, training of trainers and STEM centres, a more strategic level is to be reached. EASTEM aims to provide partner institutions with the knowledge to develop their own processes for continuous integration of good practices into their STEM educational ecosystem. With support on a strategic level from university management, STEM activities are more sustainable.

IMT Atlantique, France engages with partners on how to better reach university management (e.g. programme leaders and deans, vice-rectors and rectors). They work to develop a strategy, canvas and maturity tools for continuous integration of competence development and EASTEM models into various levels of university education. Anchoring the need for support on a strategic level leads to sustainability of the various action plans, at short to longer terms. In addition, designed tools should lead to a new way to interact with stakeholders in the design, development, operation and revision of STEM university education according to various needs or more formal requirements.

3. CAPACITY BUILDING IMPACTS

EASTEM addresses university-enterprise cooperation, entrepreneurship and employability of graduates for the Asian region. Student-centred competence development within STEM education and active engagement with

industry should help bridge the skills gap in our partner countries and improve graduate employability.

STEM education centres, similar supporting units or established groups of like-minded lecturers have been set up at partner institutions and provided a focal point for STEM education activities including external stakeholders such as high schools and companies. Through a questionnaire and interviews, we have developed a framework aimed to support the Asian partners including eight themes for university-industry collaboration (Rouvrais et al, 2020), which provides the foundations for improving local industry engagement strategies and processes in partner institutions. In 2020-2021 the STEM education centres should incorporate and pilot various student-centred STEM activities involving corporate partners, lecturers, teachers, and university and high school students.

According to our Asian partners, the EASTEM project has created value by building strong national and international networks, promoting cooperation between the EU and the partner countries, between partner countries and within partner countries. Elevating the Training of Trainers courses to a national level as our partners have done in Thailand and Indonesia and intend to do in Vietnam strengthens the potential for wider dissemination of methodologies inspired by European universities, thus promoting voluntary convergence with EU developments in higher education.

With our focus on improving the quality of higher education and enhancing its relevance for the labour market and society, EASTEM objectives are also in line with the new EU Skills Agenda, more specifically increasing STEM graduates and fostering entrepreneurial and transversal skills. Lecturers from our three European partners gain additional insight and perspective on SCL teaching approaches and industry engagement and establish new partnerships with colleagues in Asia.

Through the STEM centres, partner universities have strengthened relationships with industry partners and high schools. For example, when launching a STEM centre in November 2019, Mahidol University (Thailand) signed a memorandum of understanding with Imagineering Education Company. Partners in Vietnam and Thailand emphasize the potential for their STEM centres to establish cooperation between academia and industry. Partners in Thailand have also pointed out that the EASTEM Training of Trainers courses help improve the quality of education, with the potential to transform teaching and learning philosophy and inspire lifelong learning.

Vietnam's government recognizes STEM education as a driving factor for a strong labour workforce that meets the requirements of the 4th Industrial Revolution. For example, in Thua Thien-Hue province, EASTEM's activities connecting universities with high schools and industry partners are also in line with the province's ambition to develop a smart city urban cluster.

4. CONCLUSIONS

In EASTEM we focus on STEM education and we go beyond methods. Drawing from successful strategies to address the skills gap, we aim to strengthen student-centred competence development by taking a holistic approach also by including computational thinking.

By jointly developing the Training of Trainers course methodology, Asian partner university lecturers have been trained to design, teach and assess STEM classes using student-centred approaches. The Training of Trainers course evaluation results have shown how participating lecturers have increased their knowledge and skill in applying student-centred approaches into their teaching.

These core strategies can be taken as the European model for how learning and teaching in the STEM area could be enhanced. They are based on research on students' learning of the discipline and do not prescribe certain teaching methods as being better than others. Instead, these strategies can (and should) be contrasted to formalized "teaching methods", where certain predefined protocols for how the teaching should take place are to be followed.

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