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Encouraging Student-Centred STEM Learning in HE: A theory-based project in Asia

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***Abstract*— Student-Centered Learning (SCL) is a way to motivate students to learn, which in this project is applied to STEM education at university level. This paper presents experiences with running a project based on a theory-driven approach to inspire change towards SCL in three Asian countries. The ultimate aim with the project is that the students develop relevant professional competencies in their STEM subjects.**

Keywords—STEM education, student-centered learning, international collaboration, mutual learning, competence development, employability

I. Introduction

The demands and expectations on the competencies of the future academically educated labour force are continuously changing [1]. Not only do the newly graduated students need to master the disciplines, they also need to have other competencies to meet the requirements of the labour market. Among these crucial competencies are to collaborate, to present, and to work in complex (for example culturally diverse) environments [2]. Thus, universities must consider these requirements in their teaching.

One of the ways of reaching these aims is through student-centred learning (SCL) [3]. Here, the impetus for the students' learning is moved from the academic teachers to the students themselves. This must be done without the teaching losing sight of the disciplinary knowledge and skills.

In this paper, we describe and analyse a project, *Euro-Asia collaboration for enhancing STEM education, EASTEM* (see [4], [5]) that is aimed to develop the teaching of professional competencies and to promote SCL in STEM (Science, Technology, Engineering and Mathematics) higher education at ten universities distributed over three Asian countries. The ways in which SCL is implemented varies due to, for example traditional, disciplinary, social, economic and cultural factors. Each university, with its "life", its setting, and its actors, is unique.

The paper is structured in the following way: First, we set the stage by discussing the complexity of learning and consequences for considering learning environments. Then we give an overview of the theoretical background of professional competencies and SCL. From this platform we discuss how these concepts were implemented and disseminated during the EASTEM project. Finally, we discuss the results and the learning outcomes from the project.

II. Understanding the complexity of learning

Learning is a multifaceted concept that can be understood in different ways and that can take place in a multitude of different contexts. With the aim of discussing this diversity in the EASTEM project, we briefly mention a few theories of learning that are directly or indirectly relevant.

The brain, and the individual, is in focus in cognitive perspectives. Here learning is, in most variations of the perspective, seen as an individual endeavour, giving the teacher a "classic" role of presenting or supporting transfer of knowledge, with teaching being centred around lectures and written exams. [6]

Moving towards teaching that supports SCL, other perspectives come to the fore. Phenomenography takes a more collective perspective in its description

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of learning. The outcome of a phenomenographic investigation is a set of hierarchically ordered categories, each of which describes one way in which a phenomenon could be understood. These categories can vary from elementary understandings of what learning means, as for example learning of unrelated facts, to more complex perspectives such as seeing learning as developing the self and a means to change society. Here it is argued that learning means coming to see something in a new and more complex way. [7] Furthermore, variation theory, derived from phenomenography, offers a structure for the interventions in the teaching and theoretical, as well as practical, underpinnings for the empirical work in this project [8].

A different perspective can be found in the socio-cultural perspective, where learning is described as taking place in the interaction between the learner and the context of his/her learning [9]. As SCL aims to empower the students to get a higher degree of control over their own learning, this perspective is clearly relevant for EASTEM

As can be seen from the discussion above, different perspectives of learning have different foci. Biesta discusses three correlated aims of education to construct a perspective on learning, and consequently teaching. His work is often referred to in disciplinary educational research. According to him, education is directed towards the following components (i) qualifications (knowledge, skills, theory, etc.) (ii) person-formation (identity, subjectification, etc.) (iii) socialisation (values, world-views, attitudes, etc.). [10]

These different perspectives (or theories) of learning open different possibilities of finding ways to develop teaching. This diversity has been crucial to our project.

A. Professional Competencies

Professional competencies are in focus in the EASTEM project, as it aims to broaden education to prepare graduates for the complexities of today's society. Despite there not being any universally agreed definition of the meaning of the concept professional competence, the gist can be described as encompassing characteristics that are associated with being a professional. These characteristics vary from profession to profession, and from culture to culture, where knowledge of the relevant subject and how to apply such knowledge in practice is a core part. There are also more generic aspects associated with being professional, such as being able to collaborate in heterogeneous teams, navigate cultural differences, follow the development of the field, and interact in various settings with different stakeholders to mention just a few. [11]

The latter aspects of professional competence are and only rarely understood in terms of how to prepare for them in education. However, the challenges of today, both on local and global arenas, place a demand for an integration of development of a rich set of professional competencies in education. There is thus a need for unveiling what constitutes professional competencies and how to address development of them in education. The CoLeaF model [12] is such an attempt and recent ACM/IEEE curricula descriptions (CC2020 [13]) are based on use of competencies. The CoLeaF model builds on the idea that a competence consists of an integration of knowledge, skills, and attitudes. It is important to understand that integration is related to a particular context for the competence in question. All components are essential for what constitute each particular competence.

The high relevance of context might seem problematic for attempts to set up academic education that aims to prepare for general situations. It is however equally important, if not more, to experience and understand how context plays a part in developing professional competencies, than achieving an abstract, generalised education that possibly could be applied in all contexts. In the EASTEM project it is of great importance to let the local situation govern the professional competencies to be addressed.

B. Student-Centered Learning

By giving more control over the learning to the students, the different versions and implementations of SCL are identified as valuable for motivating students to learn [3]. This is said even with the fact that SCL has a variation of definitions. One way is to see it as learners having the opportunity to decide the material to learn from and how to go about the learning. Another meaning is that a teacher sets up learning environments in a rather controlled manner, but where the learners are guided to be active as they learn. Common to the different interpretations is the view that learning should take place in the zone of proximal development [14], where "a more knowledgeable other" can support the learner's own learning and should build on constructivist learning theories (see [15] for application in CS Education). The idea is that learning should be meaningful for, and within the reach of, a learner's current interests and abilities.

There are many ways to enhance SCL in a STEM education in Higher Education (HE). Still, the implementation selected should be founded in a good local knowledge of the context of the educational setting, as well as on the principles of SCL. In short, setting up SCL learning environments is a professional competence for teachers, and a major aspect of the EASTEM project is to facilitate the development of such a competence.

III. EURO-ASIA COLLABORATION FOR ENHANCING STEM EDUCATION, EASTEM

The EASTEM project, which started in early 2019 and that will end late 2021 is a EU sponsored capacity-building project with the aim of improving employability of STEM graduates from ten Asian partner universities in the following cities: Thailand (Chiang Mai, Hat Yai, Bangkok), Vietnam (Hai Duong, Ho Chi Minh City, Hue), Indonesia (Bandung, Yogyakarta, Sitoluama, Jimbaran), see fig 1. [4]

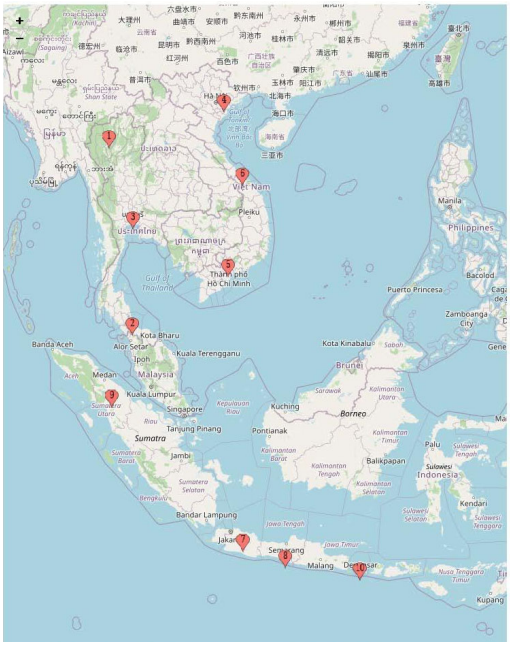

Fig.1. The locations of the Asian partners

A. The project

The project discussed here, implementing SCL in STEM education, was done in one of the subprojects of EASTEM, in [4] labelled "Pillar 1". The project was organised in a collaborative way, so that all participants, Asian as well as European, contributed to the whole and jointly agreed on what needed to be done, and why this should be done. This way of organising was according to the guidelines of SCL, where the learners, in this situation the Asian academic teachers, were in charge of their own learning. Most universities organised local courses for their academic teachers. In Indonesia and Thailand national courses have also been organised for teachers.

B. Enhancing Student-Centred Learning

A primary focal point of the EASTEM project involved incorporating SCL practices and methodologies in the STEM classrooms. As the project continued, it became clear that buy-in and understanding of SCL practices were well-received, though the COVID-19 pandemic made in-person meetings impossible. Our partners were quick to adapt their teaching on-line solutions and to develop student-centered approaches, despite the new and difficult situation. They shared best-practices between one another, and explored and contributed to SCL by reflections and practicing methodologies from their local academic culture.

In the midst of the Covid-19 pandemic lock-down, we organised a series of workshops, CUP EASTEM (Collecting, Understanding and Publishing for the EASTEM project), in order to promote evaluations of the project using qualitative research methods. All partners participated, and have until now collected large amounts of data, written a number of abstracts and have submitted a few publications.

C. Evaluating Changes in Teaching

Throughout the project, the EASTEM community has cooperated closely in developing and piloting "Training of the Trainer" courses (ToT courses) in SCL for colleagues, local or at a distance. The project has had physical meetings at different universities before the pandemic. Throughout the project different forms of evaluations have taken place. Already after the first meeting in Uppsala in May 2019, all participants reported that they understood the concept of SCL. This had, to the second meeting in Bangkok in November 2019, advanced to becoming insights in how ToT courses could contribute to their lecturers' use of SCL.

Evaluation results also demonstrate a shift in attitudes from the early days of the project, when some teachers participating in the project were expecting to be taught what to do, to the present day when all universities are independently running and evaluating their ToT courses. In developing their teacher training, universities have tackled their own challenges, whether it is making ToT courses in SCL mandatory for all lecturers, convincing senior lecturers of the benefit of SCL approaches or securing support from university leadership. A further result is that the Asian universities have conducted and evaluated their own ToT courses.

A major achievement of the EASTEM project is that the project has connected pioneering universities in SCL in Thailand, Vietnam and Indonesia who are now further developing their teaching practices, both individually and in national teams. By working together, universities in these countries have not only improved their own teaching but also created a nation-wide impact by extending teacher training to large numbers of lecturers from other universities and making policy recommendations to ministries of higher education.

Having started to improve teaching and teacher development in SCL, partner universities have been well positioned to make progress also in other areas identified as important by our project. For example, the ToT courses have been given additional visibility within universities through the establishment of STEM centres at all Asian partner universities. Through local discussions on SCL and other ways to enhance teaching practices, SCL has also served as a way to connect with industry partners and include competences required in the labour market in curricula and study programmes.

LESSONS LEARNT

We are happy with the development because it exceeded our goals and expectations. This is an example of co-production of knowledge and active participation of everyone in the project. Consistent communication or regular check-ins provided insight and maintained momentum and personal contacts. The trust that was created in this way was crucial for the

transition to running the project online during the pandemic. Here CUP EASTEM was a powerful tool for our partners to learn from one another, to jointly analyse the students' statements about SCL (collected as qualitative data), and to work together on more concrete issues, which further added a social dimension within the project for many participants, particularly during the pandemic.

The ideas underlying this project are founded in theory on learning within STEM and in the theoretically based concepts of professional competencies and SCL. We, the authors of this paper, are convinced that EASTEM would never have been initiated if it was not for the theoretical underpinnings that gave us inspiration as well as guidance in the application and in the work. Further, we do not believe that the ideas would have had such an acceptance if they were not possible to argue for in theoretically sound ways.

IV. Conclusions

The EASTEM project illustrates the importance of both anchoring development on a theoretical foundation and to adhere to local needs and conditions. The theoretical underpinnings provide stability regarding the direction of change, and it is essential to be aware of where the faculty and staff developers are in terms of readiness to adapt their teachers to a SCL approach.

Constructing a joint theoretical base has been pivotal in providing a shared understanding of the different local approaches to encourage teaching aiming to SCL in STEM education. This has facilitated discussions on methods to encourage teachers to use methods leading to SCL in their teaching and results in student learning. In summary, the EASTEM project has been a good learning experience, offering many new insights, for everyone involved.

Acknowledgment

We, the authors, acknowledge the EASTEM Asian partners for their consistent dedication and active project participation. Each partner not only provided valuable insight and perspective in the challenges and needs of their communities, but went above expectations by stepping out of their comfort zone to share, successes, struggles, and challenges. This made our team stronger and better able to adapt to the local academic environment.

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