Implementation of Internationalised Master Degree Courses in Nanoelectronics and Nanotechnologies in Asian Universities

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***Abstract*— The NanoEI project has so far enabled creation of twenty seven courses that facilitated transfer of knowledge in nanoelectronics and allied subjects between EU's higher education institutions that have been part of the project with the partner institutes in China, Malaysia, India and Israel. This paper summarises the results of the pilot test in the four Asian countries before the pandemic situation and presents the new teaching initiatives during the COVID pandemics to rise the effectiveness and attractiveness of distant education.**

Keywords—engineering education, collaborative course development, nanoelectronics, nanotechnologies, open educational resources

I. INTRODUCTION

Nanoelectronics is driving the market space of Connected car, Cyber security, Portable & Wearable, Photonics - Harnessing the Power of Light, and Internet of Things. Benefits are in areas of Energy Efficiency, Connected Devices, Security, Health and they are through nanoelectronics technology solutions by way of innovations in RF, analog, power management, interface, security and digital processing, which in turn allow product differentiation through features size, weight, etc., cost of ownership and time-to-market.

Making above possible, a nanoelectronics industry then offers broadest product portfolios and serves customers across the spectrum of electronics applications with innovative semiconductor solutions for Smart Driving and the Internet of Things. By getting more from technology, the nanoelectronics industry thus leads Integrated Device Manufacturer serving all electronics segments, positions as a leading technology innovator, and, has quality expertise in capacity requirements - nationally as well as globally, visions sustainability leadership responsibility.

Within this framework Erasmus+ has then considered a multidisciplinary Nanoelectronics project; namely, "Internationalized Master Degree Education in Nanoelectronics in Asian Universities", which aims at transferring knowledge between EU higher education institutions and institutions in China, India, Korea and Israel, and between the partner countries' institutions to modernize curricula in Nanoelectronics

II. NANOEL-ASIA PROJECT

The aim of the project is to modernise the curricula in nanoelectronics and in Nanotechnologies in eight Chinese, Malaysian, Indian and Israeli universities through collaborative development of nanoelectronics courses and through equipment of new laboratory for practical work of the students. Unfortunately, the Covid situation impeded the use of new laboratories until now.

The main project objectives are;

- To analyse the educational needs in nanoelectronics and to define the learning outcomes.
- To design syllabi and course content for the learning outcomes.
- To develop e-learning materials and to establish a platform for knowledge sharing inside Asian, Israeli and European academy.
- To start the implementation of the joint courses delivery during the last project year.

The project partners are the Technical University of Sofia as a co-ordinator, Politecnico di Torino and South-East University of Norway from Europe and University of Malaya and University Tunku Abdul Rahman from Malysia, University of Chinese Academy of Science and Chongqing University of Technology from China, Tel Aviv and Bar Ilan Universities from Israel, University of Mumbai and NIIT University from India.

III. NEW SKILLS FOR THE NEW JOBS IN NANOELECTRONICS

In the project a mapping of 1) the industry needs for competence within micro- and nanotechnology, 2) the universities' need for and motivation to use OERs in micro- and nanotechnology and 3) students' desires and interests in utilizing OERs have been carried out.

The questionnaire for industry and researchers was to define the contents to be taught [1]. Teachers were asked about the methods and techniques they know or they would like to learn to use in on-line courses. The students were asked about their experiences and attitudes towards e-learning and their expectations.

The representatives of the employers were actively involved in the need analysis. The industry survey was mainly targeting companies in China, India, Malaysia and Israel. It was distributed to more than 40 institutes and around 100 researchers in India, to researchers and companies in Malaysia (PETRONAS, MIMOS, ST Microelectronics, Abbe Group, Time dot com, Chemsil Air & Water Sdn Bhd, Permulab Sdn Bhd, Geocycle Environmental Services Sdn Bhd, Info Kinetics Sdn Bhd, Deseo Enterprise, Panasonic Sdn Bhd, CREST), researchers (University of Malaya, University Tunku Abdul Rahman, Multimedia University, National Defense University of Malaysia, Universiti Kebangsaan Malaysia, Universiti Putra Malaysia, Universiti Sains Malaysia, International Islamic University Malaysia, Monash University Malaysia, The University of Nottingham Malaysia, Universiti Teknologi Malaysia, Tunku Abdul Rahman University College, Universiti Malaysia Pahang, Sultan Idris Education University, Universiti Teknologi PETRONAS, Universiti Teknikal Malaysia Melaka, Taylor's University Malaysia, Universiti Selangor, Segi University, Universiti Malaysia Terengganu, German-Malaysian Institute, International Medical University, Open University Malaysia, Nilai University, Universiti Malaysia Sarawak), to researchers and companies in China (University of Chinese Academy of Sciences, National Centre for Nanoscience and Technology, BYD Inc, BOE inc. and so on).

As expected, the large companies in technology with more than thousand employees were from China there was a majority. The companies India and from Malaysia in majority are with less than 200 employees. The survey focus was on what the skill needs are and how many employees would be employed within specific sectors. The different sectors were listed in the questionnaire, and they represented the domains in which the eleven universities could offer as open courses.

The results of the skill analysis were presented in [2].

IV. New Courses in Nanoelectronics

According to the results of the skill analysis, 27 courses were developed by the partner universities in materials for nanoelectronics, devices, systems and applications [2]. The courses were developed as open educational resources in a Moodle environment with the use of different media: videorecorded lectures with presentation of the PowerPoint slides with the record of the teacher on the screen, HTML courses with animations, self-evaluation tests and exercises [3, 4].

The following courses are developed with different e-learning materials: Nanomaterials for Electronics, Nanomaterials Synthesis and Characterization Techniques, Carbon Nano Tubes and Applications, Graphene Nanoelectronicsp Advanced Nanoelectronic Devices: miniaturization of transistors and the resulting impact on their performance, Sensing at the Nanoscale, MEMS Design, Bioelectronics, Socio- Ethical and Environmental Aspects of Nanotechnology, Microelectronics Technology, Nanoelectronics for ICT, Design of Nanoscale MOS ICs, Advanced Optoelectronic Instrumentation & Materials, Top-Down ASIC Design Flow, Nanoelectronics Quantum Phenomena in Nanoscale Systems, Nanotechnology for Solar Energy Utilization, Functional Nanostructure: Synthesis, Characterizations and Device Applications, Nanoelectronics: Processes, Computation and Design, Nanoelectronics Systems: Future Nanoelectronic Devices and Manufacturing Processes, Nanoelectronics Systems: Applications- Quality living with Smart Future, Present to Future Business Systems [5-7], Bio Molecular Nano Computing, Memristor-Based Neuromorphic Systems.

V. Exploitation

Aim: The purpose of the exploitation is to ensure that the user needs are met, the project results are durably implemented, i.e. to ensure the sustainability of the project results [8].

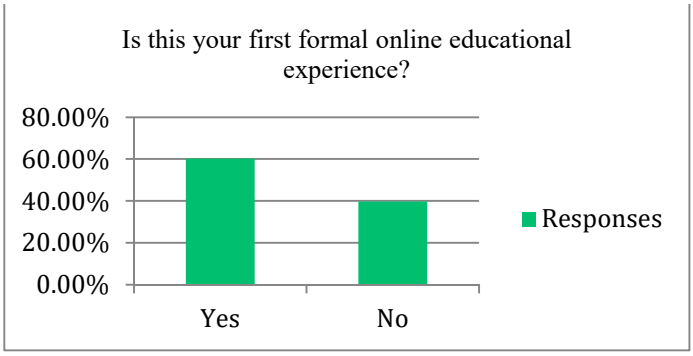
The implementation of the new curricula started during the second year of project lifetime with pilot test with small groups of learners followed by the field trial as a part of the regular curricula of the MSc degrees at each partner university. Unfortunately, because of COVID situation first the Chinese and later all universities were closed and the education is delivered already one year on-line. Our new initiatives for motivating the students in such a long distant education are summarised in the next section.

Before the pilot test one training seminar was organised by Tel Aviv University for the project steering committee and representatives of all partner institutions and then, the trained representatives of each higher education institution perform training at their university.

A. Pilot test

The pilot test of the courses was performed in 2019 in two semesters according the academic programme at each university with small groups of learners. 282 students took the new courses. A survey was used to measure the students' satisfaction and their experience with the courses.

The results are presented on Fig. 1 and Fig. 2.



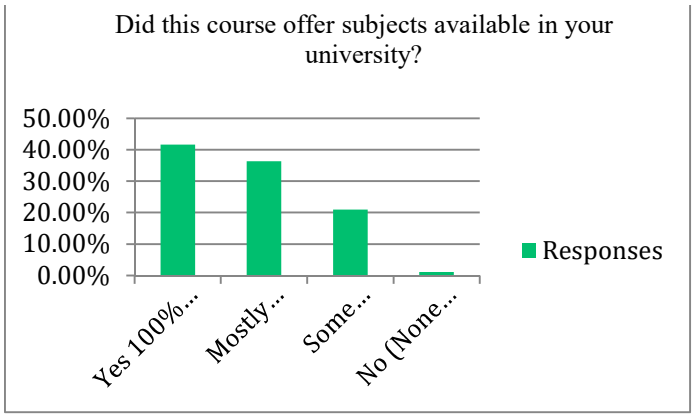


Fig. 1. Statistics of the answers to the general questions in the pilot test survey.

The majority of the students' positive opinions can be expressed with the following three:

- "This method of following the lessons is very nice since it is possible to organize yourself in the best way according to your personal commitments. Moreover, in the NanoEl site there is a large number of very interesting courses that could be a deepening of what has already been studied or even an unknown topic that you want to learn, so from this point of view it can only be a positive point. In many courses there are also lessons explained by different teachers, making it clear that each of them explains their part of competence making the course infallible. Another point is the willingness to supply material and test yourself with quizzes.
- Being a working student, this is much better learning experience for me.
- I think is quite useful for a student, because, in addition to the two extra courses that I chose to attend, there were different other courses that could be chosen and all of them were interesting in their field of application."

Most of the disadvantages mentioned by the students are related to the lack of possibility to discuss with the teacher, lack of interactivity and need of exercises and quizzes, i.e. all related to the interactivity:

- "There is no interaction between the student and the professor, so there is no possibility to solve and clarify any doubts or incomprehension and also there is no possibility to discuss about any ideas regarding the topic;
- Maybe it will be good to have a short quiz at the end to know if we have understood the main ideas;
- It's sometimes difficult to follow, I think some exercises in between could be useful to be sure the principal aspects are understood. More images could be helpful."

After the pilot test and to respond to the needs of student for more self-evaluation tests and exercises, the course developers made the corresponding changes and improved the courses preparing them for the implementation – field trial.

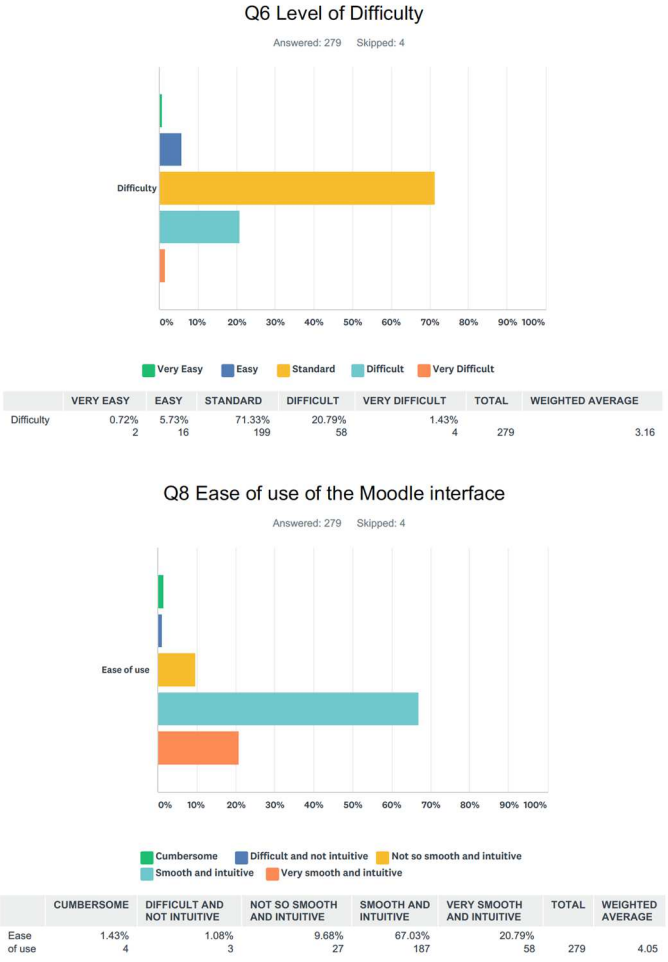


Fig. 2. Attitudes of the students to the course content and e-learning environment.

B. *Field trial*

The field trial was done with larger audience 537 students. For nanotechnologies and nanoelectronics this is a very high number of MSc students. In fact, it was the formal implementation of the innovated curricula with all students.

The results of the survey are presented on Fig. 3.

The students liked the self-evaluation tests and exercises but they still preferred face-to-face education to the distant one. What they appreciated the most was the delivery of teaching from seven countries in Asia and Europe: "This mode of learning has the great advantage of giving you access of a lot of information from different institutes all over the world and this is a great opportunity to share knowledge."

After successful assessment, the students obtained a certificate from the university delivering the course with the corresponding credits and the local grade of the host institution system with corresponding grade of the student's home institution system. So, the full cycle of virtual mobility was realised in NanEl-Asia project.

Fig. 3. Main results of the survey during the field trial

VI. Reaching Beyond the Realms for the Learners Across Continents

The NanoEI project has so far enabled creation of 27 courses that facilitated transfer of knowledge in nanoelectronics and allied subjects between EU's higher education institutions that have been part of the project with the partner institutes in China, Malaysia, India and Israel. The curricula of the institutes in the Partner Countries were not only developed but also modernized with extensive deliberations by the project partners (now) online as well as offline in the pre-COVID period.

With the COVID pandemic surging and impacting teaching and learning across continents, our group has taken a leap in terms of disseminating the knowledge by engaging classes live with the learners across countries. Right from meeting time zones from Asia to Europe to cutting across cultures we have mapped it all. Our live sessions enable the learners across the world not only to interact but also equip themselves with the fundamental principles and latest breakthroughs in fields of engineering, optics, bio nanoelectronics and other niche areas that span the expertise domain of the faculty in our project.

Our team is an appropriate blend of engaging speakers, skilful mentors and guides who believe in the adage "Teach what you know; learn what you do not know".

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