Internationalizing Engineering Education With Phased Study Programs: India-European Experience

Krishnashree Achuthan
Amrita Center for Cybersecurity Systems & Networks
Amrita Vishwa Vidyapeetham, Amritapuri, Kollam, Kerala

Maneesha V. Ramesh
Amrita Center for International Programs
Amrita Vishwa Vidyapeetham, Amritapuri, Kollam, Kerala

Sasikumar Punnekkat
Dependable Software Engineering Department
Mälardalen University, Sweden
sasikumar.punnekkat@mdh.se

Raghu Raman
Center for Research in Advanced Technologies for Education, Amrita Vishwa Vidyapeetham, Amritapuri, Kollam, Kerala

Abstract— **Most of the critical challenges seen in the past decades have impacted citizens in a global way. Given shrinking resources, educationists find preparing students for the global market place a formidable challenge. Hence exposing students to multi-lateral educational initiatives are critical to their growth, understanding and future contributions. This paper focuses on European Union's Erasmus Mundus programs, involving academic cooperation amongst international universities in engineering programs. A phased undergraduate engineering program with multiple specializations is analyzed within this context. Based on their performance at the end of first phase, selected students were provided opportunities using scholarship to pursue completion of their degree requirements at various European universities. This paper will elaborate the impact of differing pedagogical interventions, language and cultural differences amongst these countries on students in diverse engineering disciplines. The data presented is based on on the feedback analysis from Eramus Mundus students (N=121) that underwent the mobility programs. The findings have given important insights into the structure of the initiative and implications for academia and education policy makers for internationalizing engineering education. These included considering digital interventions such as MOOCs (Massive Open Online Courses) and Virtual Laboratory (VL) initiatives for systemic reorganization of engineering education.**

Keywords — International Engineering Education; Erasmus Mundus, Distance Education; Global Engineers

I. INTRODUCTION

The innovations in modern engineering have undergone over five significant leaps since the eighteenth century [1]. The expectations of what engineering should deliver to the society are much more today than ever before. With shrinking natural resources, increasing population, reduction in the overall quality of our environment, the challenges left to solve are exponentially complex. On the other hand, the tools available to modern societies, the growing societal prosperity, crowd sourcing attempts to resolve problem have created promising pathways to engineering social responsibility. Internationalization of engineering is caused by key phenomena, such as global challenges and global markets. The globalization cuts across people, products, services, environment etc. and is fuelled by the unifying presence of information and communication technologies. In effect, the outcomes of engineering education go beyond traditional transfer of knowledge. Issues in the forms of language, cultural and technological inequalities will certainly pose as a great threat for a world with vanishing political borders [2] Therefore, efforts are to be made at the university level through workshops, interventions like capacity developing activities and collaborative research studies. For instance, if a particular country has been able to develop a well developed laboratorial expertise, such programs help to initiate workshops in that nation so that students across the globe can come and participate in the learning experience.

Many universities feel in order to keep international ranking, they need to provide attractive programs [3] to prospective domestic and international students. World wide academic ranking agencies give over 25% weightage to various aspects of internationalization such as student exchanges, international faculty and most importantly international reputation. This precisely reflects the extent of globalization integrated by a university to make it appealing to an international crowd [4]. Today, millions of students go abroad eager to gain knowledge and expertise in what is not traditionally taught in classrooms [2,5]. Globalization of engineering education aims to prepare technical graduates with exhaustive knowledge not only to work within the home country but also work in other nations [2,6]. This helps equip them culturally and technically to address important globalized socio-economic problems. With dedicated international centers at most prominent universities, a plethora of hybrid programs that encompass exposure to international curricular and teaching pedagogies exist today. They include: 1) Twinning or Exchange programs where courses that are offered domestically or internationally are recognized by both host and foreign universities that ultimately results in a degree that the student have registered for and 2) Dual or Joint Degrees where in either one or more degrees may be offered by host and/or foreign university based on completion of degree requirements as postulated by each one. One of the most prominent programs for student exchanges has been European Union's (EU) Erasmus Mundus programs [7]. The primary objective of Eramus Mundus programs have been to improve quality of eduation as well as promote international dialogue through cross-cultural academic cooperation. More than 18000 scholars and degree holders from over 175 countries have benefitted from this program.

Engineering institutes have seen a dramatic surge in terms of their growth across India. However, the demand from the industrial sectors far more outstrips the supply. Although in a nation like India manpower is definitely not an issue, it certainly becomes an issue when the nation fails to supply quality professionals to an extremely knowledge intensive industrial sector like engineering [2]. This is mainly because of the fact that the engineering educational system in India has remained largely archaic.

According to Bowden [8], the engineering institutes in India must therefore come up with arrangements that would enable the students to get proper work experience while receiving education based on theoretical knowledge. In this age of globalization, it is indeed a fact that nations cannot progress alone [9]. Interdependency is the key to growth, hence, the education sector in India must necessarily become globalized so as to ensure development. Therefore, a drive towards globalization of the educational institutes of the nation will certainly help to fill up the gap that is at present there between the demand standards of the industry and the actual quality of manpower offered by the engineering institutes.

The study therefore strives to look at how Indian education prepares students for further higher education in other countries as part of the Erasmus Mundus programs.

II. LITERATURE REVIEW

The inter-dependence and contribution of science and technology in engineering towards nature and society is depicted in Figure 1. The absolute need for development of 'complete engineers' to tackle today's challenges was highlighted by Graaff et al. [10] wherein he elucidated the integration of technical and non-technical education to enrich the learning experience of an engineer. This however requires a re-design of the curricula that continuously adapts to providing the skills and knowledge to changing landscape of professional requirements.

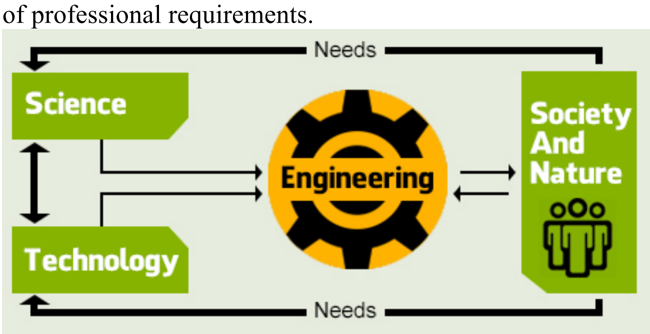


Fig. 1: Multi-disciplinary Facets of Engineering Education (adapted from [1])

A description of some of the initial European and American programs to foster collaborations is detailed by Boori et al. [11]. Although these programs were targeted towards cooperative education, and academia-industry ventures etc., the effectiveness of any of them is not addressed. Popov [12] explains that the challenges of working in multicultural groups within the higher education context depends on their respective background. Hipel [13] explains that through exchange programs and an international experience, the student's long term careers and personal development are impacted. Hipel also explains the personal traits of participants that are crucial to their success such as commitment, culture-friendliness to become a global engineer.

According to International Monetary Fund, globalization brings along with itself enormous opportunities for nations across the globe, however its impact is not felt everywhere quite evenly. Despite being globally integrated, these third world countries fail to participate fully in the process of globalization due to lack of knowledge, education and consistent exploitation by the knowledge rich developed nations [14]. EU has set a highly ambitious target of becoming the most dynamic and competitive knowledge based economy in the world by the next decade. Also, there have been many other countries who have felt the importance of developing into a knowledge-based economy for a better future. So, to make it happen such ambitious nations try to focus their efforts specifically on four major arenas. As stated in [15], these four areas are education and training, information and infrastructure, institutional regime as well as economic incentive and the last of all is the innovation systems.

The EU has pioneered trans-national mobility programs such as the Erasmus Mundus towards standardizing higher education frameworks. European Union also has been at the forefront of standardizing education by proposing and implementing the Bologna process. In a study by Salajan et al. [16] on the impact of EM program on Romanian students, shared the usefulness of EM program in giving its students more practical experience than that received in their home country. But it also a grave concern in the ability of procuring better employment by participation in EM. Apart from initiatives like Erasmus, Eureka etc. in Europe, there are many such initiatives taken in US as well.

In a deeper engagement between MIT (Massachusetts Institute of Technology) and Portugese institutions [17], internationalization of engineering program created an eco system that benefitted not only the participating students, but effected wider academic intra-institutional collaborations. The program combined engineering with innovation and entrepreneurship targeted for long term economic growth. No doubt in the fact, such programs attempt positive outcomes. However, one of the resultant effects of such educational scholarship programs is the issue of brain drain. This is in fact, according to Scavarda et al. [18] one of the ill effects of globalization of education system. The Undergraduate students once exposed to universities of the developed nations and availability of professional opportunities, start harbouring the willingness to stay back in those nations. But, with gradual development of economy, brain drain has been considerably reduced [14]. In order to deal with the problem of brain drain, activities like introduction of quality assurance systems, peer review can help to make technical degrees portable across the borders [19]. One of the advantages of Erasmus programs has been that it mandates students to return back to the home country after the study program.

To talk about the efficacy of the programs, one of the major impediments is in the form of cultural and language barriers. In order to mitigate such problems, students also as in case of Erasmus are given intensive training regarding cultural knowledge [15]. Thus as pointed out by Gawinoski [20,21], there is a large potential in these programs to churn out technically competent international students, proficient in global knowledge.

One of the key challenges in globalization is attaining economies of scale. Although today's international programs benefit hundreds of students, the number of students that are unable to participate due to the competitive nature of selection and cost run in millions. This paper elaborates the usefulness of programs such as Eramus Mundus under the external cooperation window. However we also propose extensions of this program through incorporation of relevant online theory and laboratory courses.

III. Program Details

In this section two specific programs are elaborated on i.e. The Eureca Project (European Research and Educational Collaboration with Asia) and the India4EU-1 program. These European programs had partner universities from Germany, Finland, Italy, Ireland, Netherlands, Sweden, UK, Bulgaria, Spain and France. The objectives of these programs were to provide students with an international experience in scientific and technology domains integrating these from a theoretical and practical vantage point. The project also targeted adaptation of best practices of EU-partner universities in areas of management, curricula development, research and innovations management, quality management to specialists and teachers at Asian partner universities, quality assurance of programs at Asian partner universities, guidance in implementation of European credit transfer system (ECTS) in Asian institutions, enabling mobility in educational and career markets at EU member states and Asia by joint recognition of diplomas and other qualifications, improvement of the qualifications and knowledge level of students, teachers.

A. Curricular Design

Engineering students spend approximately 4200 hours in learning as part of their four year undergraduate curriculum. The Master's students on the other hand spend approximately 2500 hours in their two year programs. In this time frame, the skill sets that students are expected to acquire include understanding fundamental principles in their disciplines of choice, knowledge of contemporary issues. Further the expectation is that they would be applying this knowledge gained to solve scientific problems in different contexts from a global or societal perspective with an ability to work in multi-disciplinary teams according to the American Board of Engineering and Technology (ABET), the European Accreditation Board for Engineering Education (EUR-ACE) as well as the National Accreditation and Assessment Council (NAAC) of India. A recent policy initiative by the University Grants Commission, India academic cooperation between Indian and foreign universities are allowed if the latter are accredited with the highest grade in their homeland [27]. With this mandate, the vision behind enhancing the cooperation capacity of the Indo-European programs in exchange of students to broaden their skillsets with international experience will ensure quality. Hence transferring of modules to supplement the program curricula is an important part of the program. Participant students included i.e. undergraduate and graduate students that were pursuing master's and doctoral studies. The programs were divided into two phases (Figure 2). In the first phase, the foundational and core courses were covered in the first 3 years (for undergraduate students) and first year (Master's students). Certain core courses that were required to be completed were taught in fast track modes that spanned between 4 weeks to 8 weeks. In the second phase, students pursued mostly elective courses at host institutions. There electives were offered to students after analyzing the curriculum, reference textbooks and coverage as part of curriculum mapping. Most students took an average of 30 ECTS credits per semester. The academic results of students from the second phase were recognized using two ECTS tools namely the learning agreements and transcript of records. One of the key enablers of the program is the recognition of ECTS credits by all participating institutions. Students spent between 6 months to a year in international universities and stayed within the campus environments.

B. Selection Process & Training

Students from the following thematic disciplines i.e. Electrical and Electronics Engineering, Electrical and Communication Engineering, Electronics and Instrumentation, Computer Science and Engineering, Chemical Engineering, Mechanical Engineering, Biotechnology and Information Technology were selected to be part of the program. A pre-selection was done prior to application to the Indo-European program. The five criteria taken into consideration for the pre-selection of UG and PG students included: academic performance (past and present), an interview and aptitude test, communication ability and record of conduct and discipline. For the doctoral and post-doctoral students, their statement of purpose and qualifications i.e. research ability was also taken into consideration.

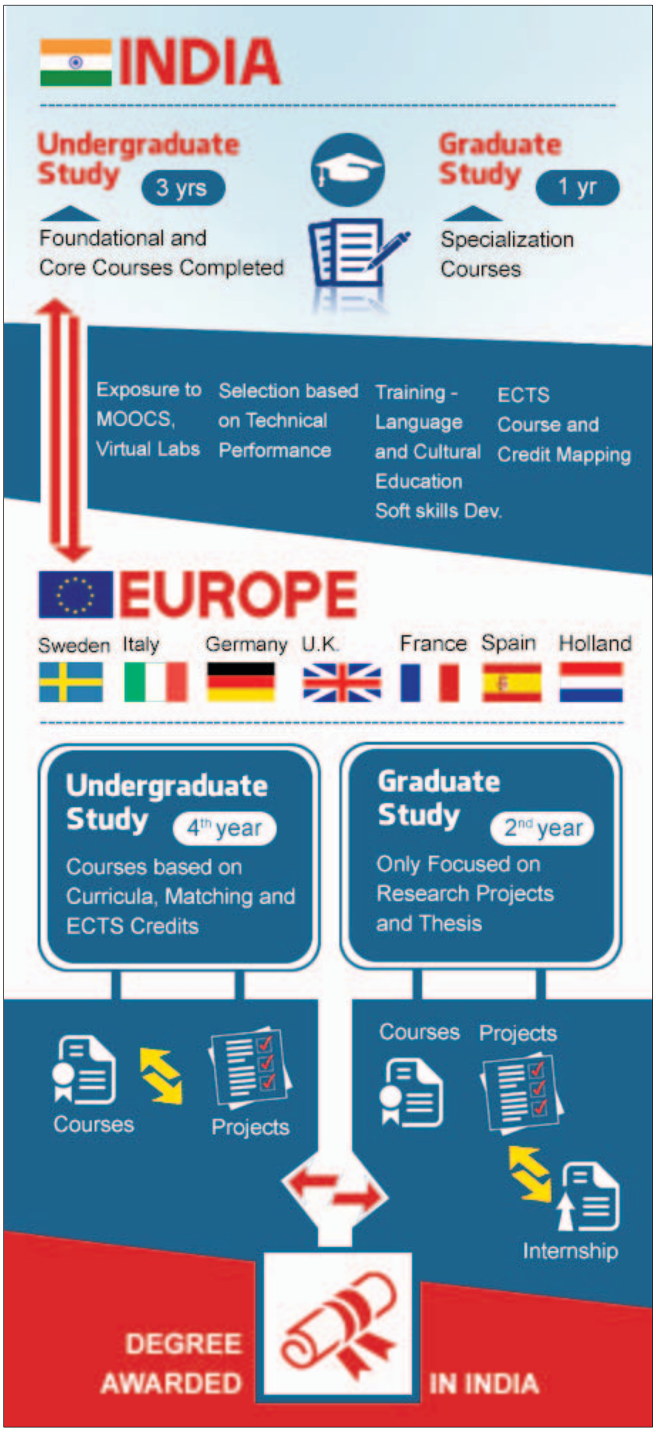


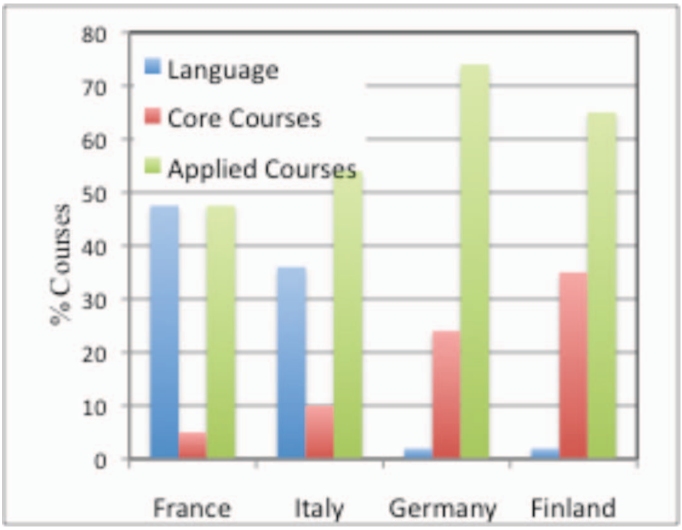
Fig. 2: Design of Indo-European Programs

The students are ranked based on these assessments and top candidates are allowed to apply for the second phase of the program.

In the second phase, students apply online giving a choice of three partner universities. The partner universities verify the candidature and grade each applicant based on academic relevance, language skills and motivation.

C. Cross-Country Variations in Curricula

An analysis of courses offered to students between at various institutions revealed the emphasis each country places on the types of courses. Figure 3 shows in Italy and France, students are required to take between 40% - 50% Italian and French language classes as many technical courses are offered in these languages. In Germany and Finland, the emphasis on international experience was placed on offering applied courses in their area of expertise. A few examples of core and applied courses that a typical computer science and engineering student received included formal methods, compilers, virtual reality, media computing, computer graphics and so on. One of the



outcomes of this variation is the number of hours students spend on conceptual learning and the exposure they therefore receive

Fig. 3 Distribution of Courses in Countries

D. Technology and Collaborations

One of the key aspects that can enhance globalization in engineering education is reaching out to students by way of digital interventions such as training students via MOOCs (Massive Open Online Courses) for content grasp, initiatives such as Virtual Laboratories (VL) [22,23,24] for practical laboratory experience and platforms for collaboration [28]. VLs are powerful tools that allow cross-institution collaboration and teachers or students can access them enriching their teaching and learning processes. These can be simulation based labs or remotely triggerable labs that only require internet connectivity and can be used by students synchronously and asynchronously irrespective of their geographic locations. These large scale initiatives (Figure 4) cater to a vast number of heterogenous learners, over 100,000 sometimes [25,26], overcoming disparities in quality of education and mode of teaching that exist between countries in a cost effective way. The potential for maximizing the learning from international experiences is much better when they are exposed to such technologies and collaborative tools reducing the knowledge gap from varying curriculum across countries.

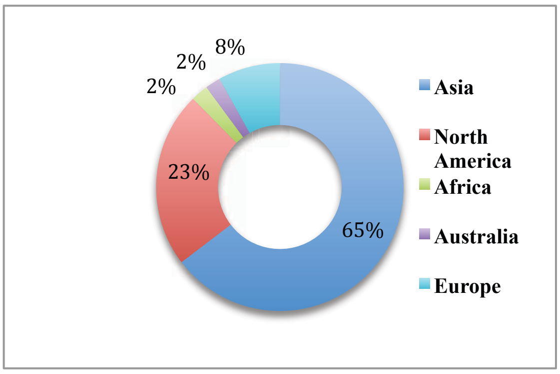


Fig. 4 Virtual Lab World Wide Usage

IV. Result Analysis

Out of the 121 participants in the study, 66% were males, 34% were females. The Likert scaled feedback questions were designed based on a pre-survey study of three students (2 males and 1 female). A total of 19 questions were given to them and discussions held to ensure that the questions were unambiguous and more importantly pertinent to their experiences with the program. The total count of questions was reduced to 14 after this initial pre-survey study.

An overwhelming 91% were very satisfied with the support and guidance given by the program coordinator. 77% of the program applicants had opted for engineering sciences followed by 23% for business & management.

Though the program provided for full scholarship, the applicants indicated international study experience as the top reason for applying while better employment opportunity was ranked lowest. (Fig.5.)

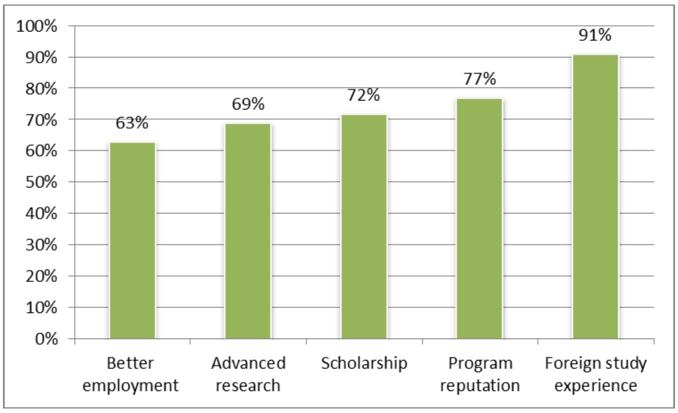


Fig. 5 Reasons for joining the Erasmus Mundus Program

An overwhelming 94% of the respondents agreed that the course work at the foreign university had global perspective. (Fig.6.)

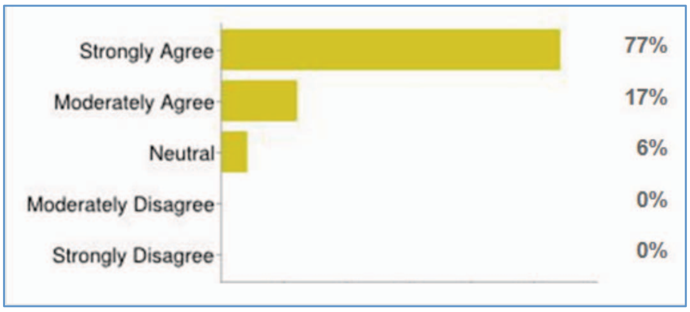


Fig.6. I found the course work to have global perspective

The area of largest disparity in education is concerned with pedagogic aspects. Many students felt problem solving was highly stressed in German, Swedish and Finnish universities. The curriculum called for rigorous assignments. This further also correlated to the type of applied courses students undertook to study. In other countries, the theory based learning was more prevalent. The number of hours the students spent on learning differed significantly based on the pedagogic delivery.

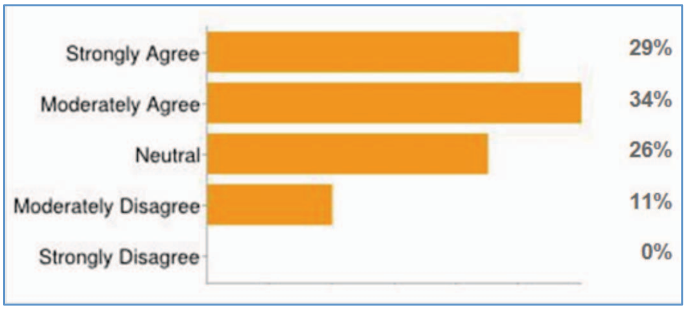


Fig. 7 I found the pedagogy to be more practical

Though the number of Indian students seeking global education is seeing slight decline in the last four years due to costly overseas education, visa rules etc., the respondents overwhelmingly agreed that getting a formal degree from a foreign university will make the Erasmus Mundus program very attractive and valuable. (Fig.8.)

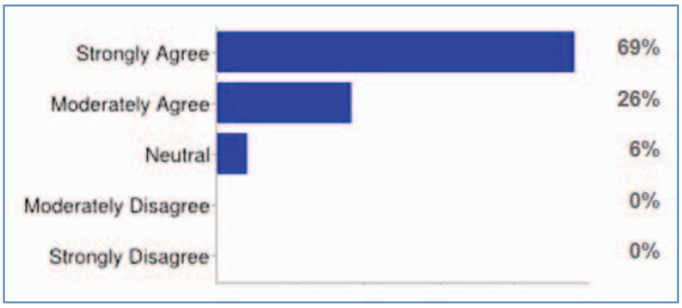


Fig. 8 Getting a foreign degree will make this program attractive and valuable.

Though language and cultural barrier are challenges students generally face in study abroad programs, interestingly this was not the case with our respondents. (Fig.9.) This was mainly due to the fact that the students were given intense tuition in foreign language by the foreign university and that many courses were offered in English.

Fig.9. The foreign language was a barrier to learning

V. CONCLUSION AND FUTUREWORK

Building a workforce that can adapt to a global terrain is a tall order for most academic institutions. By providing an opportunity to live, interact in international classrooms and research environments, the knowledge students gain can create an indelible impression on their outlook and approach to problem solving. A non-traditional approach to engineering education was adopted and presented in this paper. Mapping a curriculum that allows students to spend time in India as well as Europe for a significant part of their program i.e. between 17% to 50%, yielded a large impact of an international experience in their engineering education. Through mobility supported by Erasmus Mundus programs students were exposed to multi-cultural, differing pedagogies and engineering emphasis from 10 European countries. Results indicated that students did place high regard on international experience in their education irrespective of tougher curricular requirements and pedagogic practices in countries that emphasized study of applied courses in UG and PG programs. Language that used to be a significant barrier in attracting foreign students not too long ago is not as much a concern to students.

Our recommendations based on this work include mandating regulatory bodies such as the UGC and MHRD should mandate globalization as a high priority and have it integrated into of engineering education. By approving programs with reputed international partners, a culture of international cooperation in academic and research can be inculcated in emerging areas of science and technology. An inclusive approach to communities that would otherwise not reach out to international participation by removing the barriers of language and lack of access should be adopted. With increased incentivizing of science and engineering education as well as research a tremendous enhancement in global participation can be achieved. Funding of bi-lateral programs and projects has been instrumental in today's student exchanges amidst plaguing economic crisis. By seeding more programs between peer agencies and providing financial support, Governments could create aggressive pathways to globalization.

VI. ACKNOWLEDGEMENT

Our work derives direction and ideas from the Chancellor of Amrita University, Sri Mata Amritanandamayi Devi. The authors would like to acknowledge the contributions of faculty and staff at Amrita University whose feedback and guidance was invaluable. We would like to specially thank Ms. Bianca Buttiglione and Ms. Silvia Corosso from Politechnico Di Torino, Italy for their valuable support throughout these programs.

REFERENCES

1. UNESCO Report, "Engineering: Issues, Challenges, and Opportunities for Development", 2010. Retrieved from http://unesdoc.unesco.org/images/0018/001897/189753e.pdf
2. Barnett, G. and Wu, R "The international student exchange network: 1970 and 1989". Higher Education, 30, 4, 2005, 353 - 368.
3. Greengard, S. "Learning goes Global". Communications of the ACM, Vol. 52, No. 5, 2009, pp. 18 – 19.
4. http://www.topuniversities.com/
5. Mkherjee, S., Chanda, R., "Indian Student Mobility to European Countries: An Overview", Carim-India Research Report, 2012.
6. Berglund, A. and Eckerdal, A, "What do CS Students Strive to Learn?" Computer Science Education, 16, 3, 2006, pp 185-195.
7. Eramus Programme, http://eacea.ec.europa.eu/erasmus_mundus/index_en.php
8. Bowden, J, Capability-driven curriculum design. Routeledge Falmer, London, UK, 2004.
9. Otten, M "Intercultural Learning and Diversity in Higher Education" Journal of Studies in International Education, 7, 1, 2003, pp 12 – 26.
10. Graaff, E. D., Ravesteijn, W., "Training complete engineers: global enterprise and engineering education", European Journal of Engineering Education, Vol. 26, No. 4 2001, 419-427.
11. Borri, C. , Guberti, E. , Melsa, J. "International dimension in engineering education", European Journal of Engineering Education, Vol. 32, No. 6, 2007, 627–637.

12. Popov, V., Brinkman, D. , Biemans, H.J.A., Mulder, M. , Kuznetsov, A. , Noroozi, O. , "Multicultural student group work in higher education An explorative case study on challenges as perceived by students", International Journal of Intercultural Relations, 36, 2012, pp.302-317.
13. Hipel, K. W., "The Internationalization of Engineering Education: A Tale of Two Countries", IEEE Transactions on Systems, Man and Cybernetics, Vol. 33, No. 1, 2003, pp. 137-148.
14. Borrallo, J, "Erasmus Mundus Programme: An European oportunity for students and scholars," Engineering in Medicine and Biology Society (EMBC), 2010 Annual International Conference of the IEEE , vol., no., pp.6842,6843, Aug. 31 2010-Sept. 4, doi: 10.1109/IEMBS.2010.5626458
15. Lamancusa L, José, L "The Learning Factory A New Approach to Integrating Design and Manufacturing into the Engineering Curriculum." Journal of Engineering Education, 2007, pp. 103-112.
16. Salajan, F. D., Chiper, S., "Value and benefits of European student mobility for Romanian students: experiences and perspectives of participants in the ERASMUS programme", European Journal of Engineering Education, Vol. 2, No. 4, 2012, 403-422.
17. Pfotenhauer, S. M., Jacobs, J. S., Pertuze, J. A., Newmand, D. J., Roos, D. T., "Seeding Change through International University Partnerships: The MIT-Portugal Program as a Driver of Internationalization, Networking, and Innovation", Higher Education Policy, 2013, 26, pp. 217-242.
18. Scavarda do C., Luiz, M., Lueny M., Russel, J. "The Concept of Engineer of the Americas and Related Actions." International Conference on Engineering Education Conference Proceedings, 2005, pp. 90 – 96.
19. Alonso, S., Bollain, M., Cuvillo, C., Fernandez, M. C., Garcia, A., Santos, E, "Experiences about ERASMUS: an interchange project," Frontiers in Education Conference*, 2,* 1995, pp.4c4.1-4c4.4.
20. Gawinowski, G., Drogoul, F., Guerreau, R., Weber, R., Garcia, J.-L, "Erasmus contribution to the 2020 SESAR scenario," 27th IEEE Digital Avionics Systems Conference, 2008*,* pp.3.A.2-1,3.A.2-10.
21. Gawinowski, G., Garcia, J.-L., Guerreau, R., Weber, R., Brochard, M, "ERASMUS: a new path for 4d trajectory-based enablers to reduce the traffic complexity," 26th IEEE *Digital Avionics Systems Conference,* 2007, pp.1.A.3-1,1.A.3-11, 21-25.
22. Achuthan, K., Sreelatha, K. S., Surendran, S., Diwakar, S., Nedungadi, P., Humphreys, S., Sreekala, S., Pillai, Z., Raman, R., Deepthi, A., Gangadharan, R., Appukuttan, S., Ranganatha, J.,Sambhudevan, S., Mahesh, S., The VALUE @ Amrita Virtual Labs Project", IEEE Global Humanitarian Technology Conference Proceedings, 2011, pp 117-121.
23. Raman, R., Achuthan, K., Nedungadi, P., Ramesh, M., "Modeling Diffusion of Blended Labs for Science Experiments among Undergraduate Engineering Student", AFRICOMM Springer Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, 2013,
24. Raman, R., Achuthan, K., Nedungadi, P., Diwakar, S., Bose, R., "The VLAB OER Experience: Modeling Potential-Adopter Student Acceptance", IEEE Transactions in Education, 99, 2014, pp 1-7.
25. Thanasis Daradoumis, Roxana Bassi, Fatos Xhafa Santi Caballé, "A review on massive e-learning (MOOC) design, delivery and assessment", 8th Intl. Conf. on P2P, Parallel, Grid, Cloud and Internet Computing, 2013, pp 208 – 213.
26. Siemens, G., "Massive Open Online Courses: Innovation in Education?", eds. Commonwealth of learning, Perspectives on Open and Distance Learning: Open Educational Resources: Innovation, Research and Practice, 2013, pp 5-8
27. UGC Regulation on Academic Collaboration between India and Foreign University http://www.ugc.ac.in/pdfnews/9578034_English.pdf
28. Bijlani, K., Venkat Rangan, P., Subramanian, S., Vijayan, V., & Jayahari, K. R. (2010, June). A-VIEW: Adaptive bandwidth for telepresence and large user sets in live distance education. 2nd International Conference on Education Technology and Computer (ICETC), 2010, Vol. 2, pp. V2-219