# Preparing Global Engineers: USA-India Academia & Industry led approach

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***Abstract*—** A major challenge in engineering education today in India is preparing students with the skill set needed for a global industry. This paper describes an innovative partnership between two institutions of higher education in India and USA and a multinational corporation to address this challenge. The collaborative manner in which the industry and institutions internationalized the curriculum is a key feature of this program. This unique approach has resulted in the employees of a multinational company in India being able to get two high quality Masters-level degrees in engineering, customized to their current and future requirements at a very affordable price point. This paper looks at cost savings, collaborative course development between industry and international academia, using technology to deliver courses and on-the-job professional development program for employees while keeping the employees motivated. But there are also interesting lessons learnt regarding teaching in English, adjusting to the local cultural context and the overall integration into the Indian academic setting. The process innovation described here would be of great interest to academia, industry and education policy makers and has the potential to be replicated in the entire field of non-engineering and interdisciplinary academic programs.

***Keywords—Globalization, Industry, Internationalization, Engineering, Perception,***

## I. INTRODUCTION

A major challenge in engineering education today in India is preparing students with the skill set needed for a global industry. Foreign universities are not a complete solution to the problem, due to their high cost of education, industry relevance, regulations and other logistical impediments. Hence multinational companies are spending substantial time and funds to get their employees to be relevant for their global needs. Globalization can be described as a continuous process of social-economic development. The modern day globalization is taking place at a huge scale like never before and is one of the major influencing factors in shaping up modern life. Globalization has led to opening up of economies taking part in dynamic trading activities in diverse industry sectors. Due to changing business trends, the nature of manpower sought after by the business world is becoming increasingly globalised [1]. Universities across the globe are therefore planning out for curriculum that would educate new generation learners and help them get established on a global field. Therefore, the objective of a globalized engineering education is to increase the instrumental utilities of the engineers as per the global market needs.

It takes at least a year for an engineering professional to become productive in the industry. The Indian engineering institutes follow a curriculum that solely focuses on theories. The students get hardly any real life professional experience in the form of apprenticeship or internship and as a result of which the institutes are unable to supply quality professionals as demanded by the industry sector.

In the developed nations of the world, the engineering institutes are highly industry specific. The students are trained well so as to make them able enough to shoulder responsible tasks once they enter real life job field [2]. As mentioned already, efforts are now being made to standardize the quality of educational institutes at a global level. The programs being conducted by several universities of different nations will actually help to level the standard of education irrespective of national boundaries. In order to cope up with the challenge and to make sure that their students are proficient enough to perform as per international standards, the Indian institutes are now seen to be actively taking part in such efforts.

The study therefore strives to understand the process involved in setting up such programs, introduced in the engineering institutes for making students aware of activities that are happening in different engineering institutes in different countries and gaining comprehensive technical knowledge at global standards. These programs are usually divided into two main parts so as to prepare a curriculum with perfect blend of theoretical and practical knowledge. For instance, the first stage of a program like Erasmus takes place in India while the second half of the program gets completed in European universities. The study will specifically reflect the needs and requirements of educational programs with respect to globalization, the efforts that have been made to attain certain objectives through such programs and the range of learning that has been initiated through the programs.

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## II. LITERATURE REVIEW

The term 'globalization' has increasingly become popular in the last two decades. Globalization has gained in force and attention as it is considered to be the key to worldwide economic development [3]. However, there are critics who opine that globalization enhances evils like inequalities as it threatens standard of living as well as social progress [4]. Indeed, the impact of globalization raises debate. There are some people who actually think that process of globalization is inevitable irrespective of its good or bad influence [5]. They cite examples of such countries that have integrated to prosper while there are several other countries that have undergone a negative impact in the form of widening gulf between the rich and the poor [6]. The poor countries have even become poorer. However, there is a general agreement among all nations of the world that globalization is brining upon a significant change within the entire economic scenario [7].

So, the question that arises at this juncture is what actually and how exactly is globalization related to engineering or engineering educational system. Globalization can be defined as the process through which the geographical distance becomes a gradual diminishing factor. In other words, globalization may be considered as an intensifying agent to widen and intensify the impact of global interdependency and interconnectedness [8].

The basic idea working behind such efforts is that knowledge is considered to be the primary factor for production apart from land, labour and capital [9]. In fact, there are many economists who actually believe that knowledge is perhaps the most important means of production [10]. This is because; a knowledge based economy has developmental characteristics like improved quality, better response to needs of the consumers, reduced level of costs and production of innovative products. However, it has also been noted that technology, knowledge and innovation are primarily owned by the developed nations and by utilizing these resources the developed nations exploit the poor and technology starved third world countries [7]. Irrespective of the negative impacts of globalization, globalization has indeed made the world flat through well-established communication and transportation systems [1]. In fact, engineers are ideal individuals who have the inherent capacity to solve problems [5]. To substantiate the fact, it was surveyed that about 85% of economic growth in America had been due to the occurrence of technological revolution. Also, the prime cause behind the economic growth of the emerging nations is due to the effect of considering engineering as one of the main key knowledge workers for the purpose of capacity building.

As per a study the developing nations like India in order to compete with the knowledge based economies at the international level are required to invest and produce huge pool of technically sound engineering graduates [11]. So, building up a technologically strong workforce may be considered to be a positive step taken towards economic development. To go ahead with the idea, the nations must necessarily have to encourage development of high quality engineering institutes. This will in turn attract foreign investments as technically oriented multinational companies will flock to the nation. Also, a nation having a technologically competent work force will never fall short of industrial leaders who can alone make a space for themselves in the entrepreneurial world.

Organizations like NSF or National Science Foundation, ASEE or American Society for Engineering Education and National Academy Engineering has reportedly felt the need to bring upon a change in engineering education. These institutions in collaboration with other eminent international engineering institutions have jointly come up with programs that would lead to exchange of technological knowledge in an extensive manner. The RMIT University in Australia is also found to be taken up similar such initiatives. These universities bring out scholarship programs for competent students who would like to explore greater avenues in the field of engineering.

One cannot go global until one is comprehensively localized [7]. In other words, engineering institutes are required to develop a curriculum that would not only help students to cope up with the global demands but also feed local demands [7]. So, like Erasmus, such programs are essentially divided into two parts. The first part of the program gets executed in the home country itself, India as in the case of Erasmus. Undergraduates are given substantial theoretical knowledge on different streams of engineering. Towards the end of the first part of the program, the theoretical knowledge and aptitude of the under graduates are tested. Based on their performance, the candidates are selected for scholarship programs. The tests are more like screening for the best of the brains from the lot [7]. The selected candidates are then sent to different foreign institutions to get a practical and wider view of various technological expertise.

Therefore, from the above study it becomes evident that globalization of engineering programs is noted to be a stepping stone towards social progress and economic growth for any nation. Due to the problem solving capacity of the engineers, these professionals are to be effectively tapped to ensure capacity building and to bring about technological change. By globalizing the engineering education system, both developed as well as developing nations can mutually benefit by producing technically competent and globally and culturally proficient engineering professionals.

## III. GLOBAL ENGINEERING EDUCATION MODEL (GEEM) - PROGRAM DETAILS

The Global Engineering Education Model (GEEM) described in this section elaborates the formation of key partnerships that were instrumental in designing the program criteria followed by its structure and development. Three institutions that partnered to create this program included Amrita University (Amrita) from India, a leading Public University (PU) from the United States, and the Indian office of a German multinational company (MNC). The mutual acceptance of partners and their roles were based on consideration of each one's strengths and contributions to the program. Ultimately the program had to conform to the requirements of the regulatory bodies namely the University Grants Commission

in India, and the Middle States Commission in the United States.

The Global Engineering Education Model (GEEM) (Fig.1.) has following main components, which forms the backbone of the successful collaborative program, without any of which the richness and the internationalization aspect of the program would be lost:

- Global academia – Public University from USA, Amrita from India
- Global industry – German Multinational Corporation
- Global curriculum – Joint board of studies helped integrated the best of the knowledge from Amrita, the US University and industry (MNC).
- Global faculty: Faculty from the US university
- Global assessments: Curriculum based on case studies and examples that had global perspective
- Global infrastructure: Access to the US university labs as well as course management systems

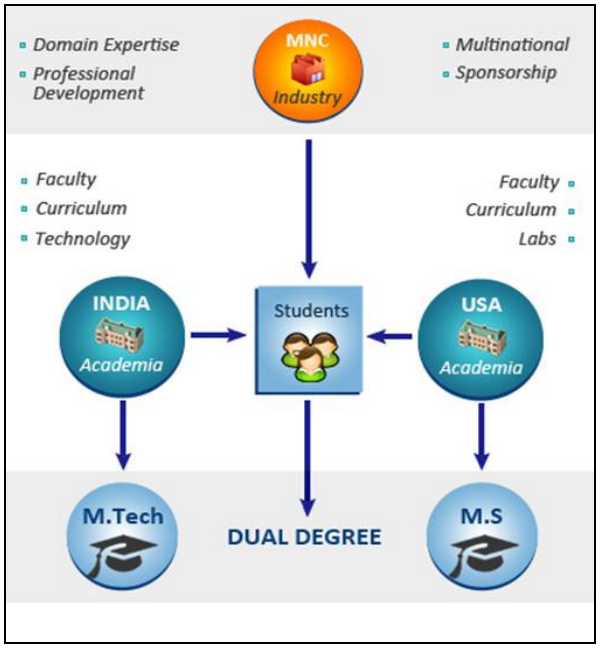


**Figure 1: Global Engineering Education Model (GEEM)**

Amrita was chosen due to its strong and innovative programs engaging foreign universities, and developing joint academic programs, student exchange programs, study abroad schemes and so on. However, these have been targeted traditionally at the academic community, including undergraduate and graduate students studying at Amrita University, as part of the traditional full time degree offering. PU on the other hand has been a pioneer in engineering education and has been consistently ranked among the top 300 universities in the world. Thus these partners were brought together in the context of transforming traditional collaborative program into substantially industry focused a global workforce.

The technical area of focus in this engineering educational program was an emerging field namely Embedded Systems. This area is undergoing dramatic growth worldwide [12]. All the major computing companies, such as Intel, Microsoft, IBM, etc., had developed a significant thrust in this area. Based upon a meeting of many advanced computing companies in Bangalore in February 2009, it was decided that, rather than focus on any one of the business application verticals such as avionics, automotive, or medical, a degree focused on concepts common to these would be more valuable.

In the design phase of the program, very early on, the crucial problems seen in the industry included employee retention and skills development. The employee attrition rate in the high tech industry in Bangalore hovers around 14%. In a recent study one of the causes for loss of employees by large companies was their inability to address the employee aspiration for higher education [13].

To ensure the program is aligned to industry needs Amrita University approached an MNC to gauge their interest in participating in the program in the area of Embedded Systems, conducted jointly with PU. When they learnt about the program objectives that addressed employee retention and incentivizing them with formal degree, they were most enthusiastic. The MNC identified a group of employees working on various technologies as the test group for this new program. Since the partner MNC in this consortium was focused on the automotive domain, a dual-degree model coupling an Embedded Systems masters degree with an Automotive Systems masters degree would be the best approach for this engineering program. We therefore met with the senior technical directors of the MNC and made a few key changes to reflect the most important concepts of Embedded Systems needed for automotive systems of the future One important aspect is that, since MNC employees made regular visits to Germany, it was important that the outcome of this program and the degree prepare them to function in India as well as Germany.

While factors for successful education programs have been identified in earlier studies [14], based on several deliberations with the stakeholders, five potential success factors for this program were identified:

1 Cost of the program
2 Course needs to be relevant to the work
3 Should be globally recognized degree
4 Should allow students to pursue higher degree, e.g. a PhD.
5 Participants should be able to continue with their present jobs while undergoing this course.

Points 3, 4 were already inherent in the initial proposal that was submitted to the MNC. The degree offered was a Master of Science from PU, which is a globally recognized degree, as well as a Post Graduate degree from Amrita University, which will allow them to pursue a PhD degree in India as well as other universities abroad if they chose to. In addition, the design of the course structure inherently catered to working professionals. The courses were designed to be modular, so that students only took once course at a time, with examinations held at the end of each module. Secondly the courses were conducted on two days a week, a Friday evening and on Saturdays, allowing the students to continue with their employment.

Seeing immediate success to the program, the MNC identified 50 employees, mainly engineering graduates who were part of the research team, and funded their full sponsorship to participate in this program. The program was offered at two of Amrita university's campuses, one in Bangalore and one in Coimbatore. Having two sites allowed the students that were MNC research staff engineers housed in both cities to participate. Thus with a class size of 25 in each city, the program was replicated at both sites.

### *A. Innovative Program Structure*

Traditionally dual degree programs would be structured such that students would earn initial credits at one university and another set of credits from the partner university and through credit recognition qualify and earn both degrees. In this innovative approach the program was structured such that the student undergoes a set of courses that earned him credits that will fulfill the requirement of the Post Graduate Degree from Amrita University and at the same time fulfill the requirements of a Master of Science (MS) Degree from PU. There were no additional courses to be completed by the student.

In order to qualify for the Post Graduate degree in Automobile Systems, a student would have to get 64 credits. Typically this would entail a student successfully completing sixteen courses with three credits each, once two credit course and two projects that accounts for fourteen credits.

The MS in Embedded Systems began as a 12-course program of study targeted at working professionals who possess a bachelor's degree in engineering or equivalent. Students admitted to the program were required to have a bachelor's degree in engineering, or equivalent. There was no entrance exam; however, students are required to pass the Test of English as a Foreign Language (TOEFL), a requirement of the PU. To qualify for an MS in Embedded Systems, a student would have to earn 40 credits, which stem from 12 three credit courses and one project for four credits. Based on the above requirement for Post graduate degree from Amrita and an MS from PU, a common course structure was derived, in which all the courses and the project that formed the requirement for the MS from PU would be part of the requirement for the Post Graduate degree from Amrita, thus leaving students to do an additional six courses and an additional project.

The schedule of the courses would play an equally important role as the type of courses themselves. PU faculty will teach during their semester breaks (May-August, and December-January), while Amrita faculty teach during the remaining months. The courses were to be taught sequentially and mainly on weekends, so as not to conflict with the weekday schedules of working professionals. Thus with the 12 courses being taught effectively by PU faculty, and thus allow for the granting of an MS degree to students who pass these 12 courses and the project. (Fig.2.)

| | Courses | Credits | Duration | Projects |
|---|---|---|---|---|
| M.Tech | 17 | 64 | 2 | 2 |
| M.S | 12 | 36 | 2 | 2 |
| Dual Degree Under GEEM | 17 | 64 | 2 | 2 |

*Figure 2 Courses and credits*

Two projects, a Capstone project and a Major project that was required for the fulfillment of the course. These projects were planned be done at the MNC itself, so as to be of relevance to them. This benefits MNC in that they could witness the positive outcomes of subjecting their employees to global learning almost immediately.

### *B. Innovative curriculum development*

Engaging the MNC for curricular development was initiated by Amrita and PU and flexibility was provided to the MNC in identifying courses that would be of interest and within the domain of Automotive Engineering for the remaining courses. Eventually, matching both the requirements as well as the expertise available the required courses were identified. To set the curriculum, multiple discussions involving all three stakeholders, Amrita, PU and the MNC were conducted. The team from the MNC included the research heads, who gave input on what kind of research the international team was engaged in and also the kind of technologies that they wanted the researchers to be trained in. This input was extremely important in identifying the needs of the industry.

A board of studies was formed with members from Amrita University, the PU from the US and the MNC. The PU shared the curriculum for the MS in Embedded Systems and with the inputs from the MNC modified some content in the courses to suit the requirements. Inherently the curriculum offered by the PU was of world class due to the rigor with which the curriculum development was done, however, for this international program, aspects related to globalization and pertinent case were used to supplement the already rich material. Amrita University offered to cover topics that were

associated with Mechanical Engineering domain, especially in Automotive Systems.

The final course structure was designed which incorporated all the above features was classified into four major tracks.

- Foundational courses: Five courses covering embedded and real-time operating systems, embedded processors and interfacing, applied mathematics, digital signal processing (DSP), and object-oriented software design.
- Embedded track courses: Embedded systems on chip, emerging computer architectures, wireless networks, embedded DSP architectures, multimedia systems, and programming multi-core architectures.
- Capstone Course: Emerging Applications and Platforms.
- Automotive Systems courses – Applications of Embedded Systems in Automotive Systems

Each course has a total of 45 hours of lectures, and the duration of each course was approximately 4 weeks.

### *C. Innovative Pricing Model*

One of the main requirements from the MNC was to keep the cost of the program low. Effectively this meant the total cost of two degrees could not cost more than half the fees that PU charges for a similar MS course for an out of state candidate. This meant the whole pricing model had to be re-examined as traditionally universities are reluctant to have a differing fee structure for similar courses offered by the university. The program office at PU was clear that the objective of the program was to have a global presence which was sustainable and thus was prepared to reexamine the pricing model. The main components of a course offering were broken down to the following:

- Faculty remuneration
- Travel/Lodging – for faculty traveling to India
- Institutional overheads at cost

With the above components, the total cost of running the program was worked out. An optimal cost was identified based on this, and the MNC was informed on the minimum number of students that would be required to participate in the program to make this sustainable.

### *D. Faculty Mapping*

Of the 12 courses that would be needed to be taught by PU, six courses were shared and taught by Amrita Faculty. This helped minimize the dependency on PU faculty that had other commitments constraining them from International travel.. The faculty who were identified had to conform to requirements set by PU with respect to their qualifications and teaching experience and were honored as adjunct faculty at PU. Thus this helped reduce compensations to Indian professors are paid at a different rate as compared to the American counterparts. The other courses that form the requirements for the Post Graduate degree were to be taught by Amrita professors. Interaction between the foreign professors and Amrita professors also resulted in adoption of best teaching practices as well as development of joint research projects.

### *E. Technology Infrastructure*

To ensure that the quality of education and no dilution of technical support, a detailed analysis of the technology infrastructure was done. As many of the courses required specialized lab set up and expensive software which was available in the lab at PU, high speed internet access was set up to access all software and lab virtually as pioneered by Amrita. This set up was found to very effective by the PU faculty teaching these courses. The course management was also done through this set up with all submissions and assessments done using the infrastructure existing in the university in the US.

## IV. CONCLUSIONS & RECOMMENDATIONS

Within India and in fact in many countries around the world, there has been growing recognition for the need for high quality global education and regulatory bodies in these countries have encouraged the movement towards this. The main regulatory body in India that oversees higher education that used to be rigid, but now welcomes foreign universities to influence the local curriculum either through their own courses or through tie up with local universities. In this context the GEEM model provides a very viable and cost effective means to immediately reap the benefits of such actions from the government. The sustainable yet retention oriented aspects of the program provides a win-win strategy to all partners in creating a work force that is able to pursue corporate goals while simultaneously enriching their academic aptitude to become global engineers.

This program that was developed is a unique model of Industry academia collaborations, where the academic partners were able to bring international quality education through a domestic academic institution to the industry at a fraction of what it would have otherwise cost. The innovative course development process, as well as the cross-listing of courses, is unique features of the program that were key to the success of this program. In addition, using qualified local faculty to teach some of the courses helped keep cost low. The willingness of the foreign university to look at a completely different fee structure also proved instrumental to the successful deployment of this program. The international curriculum that was taught provided opportunity for the local industry to participate in a world class program without physically travelling to a foreign destination. This model can be replicated for both technical and non-technical courses, and this was a vindication of the earlier experience that Amrita had with implementing a similar program with the management

school of the same foreign university and another US based MNC.

While this program was implemented successfully at the local office of the German MNC, one thing this paper did not talk about was the effectiveness of the program in enhancing the careers of the students. It is now in the first year of implementation and while the initial feedback from the students have been extremely encouraging with the MNC getting the next batch of students ready, an empirical study on the effectiveness may be done after the course is over. The objectives for the MNC to offer this higher education opportunity to their staff were to improve the employee retention rate, enhance the knowledge of the employees, as well as motivate high performers. A more thorough study of the effect on the employee motivation and retention may be undertaken.

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