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GLOBALIZATION OF ENGINEERING EDUCATION VIA A VIRTUAL UNIVERSITY

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Abstract

Fierce international competition in engineering services including engineering education has resulted in a number of attempts for globalization of education delivery. Establishment of virtual universities where infrastructure costs are significantly low, have been envisaged as one strategic way of succeeding in educational markets of developing countries. Quite often the perception is that the virtual university is a freeway via which any student in any country can be enrolled and educated. However, the scenario is not that simple. The success of a global virtual university depends on a number of factors including cultural aspects of various societies, government regulations, division of the expenditure, resources, research output, patents and the revenue. This paper first presents a global overview of engineering education both in qualitative and quantitative terms and then details the possible hindrances in the path of global delivery of engineering education via a virtual university. It also suggests ways to overcome these hindrances to arrive at a win-win situation for both vendor as well as provider nations.

Introduction

The basic education of the people of a nation is considered a foundation for national economic growth. The tertiary education of people particularly in science and technology areas plays a key role in development of technological capability of a country. Thus a strategy based on a technical education system which produces large numbers of scientists and engineers, promotes sustained growth of national economy and living standards of people reflected by high per capita income (Figure 1).

During the second half of the last century engineering education and practice in developed countries has undergone dramatic transformation. These changes mainly include post World-War 2 transition from practice oriented focus to analytical engineering science approach[1], the influence of exploding information technology on education delivery and shift from fully funded government support to partially government funded user payee educational system. The reduced government funding of student places and nationwide increased commercial competition has compelled many American, European and Australian universities to develop innovative ideas for educational delivery and explore new markets in developing countries for educational services. In fact the moves for global delivery of education can to some extent help in meeting the huge demand of engineers generated by expanding manufacturing base and infrastructure in many developing countries.

The recent student population and degree production data indicate that increase in worldwide engineering workforce will be contributed mainly by South and East Asian countries[2] who have made strategic long-term commitments to increase the engineering workforce in order to remain competitive and thus enhance their living standards (Figure 2). Huge economic growths of many Asian countries during the last couple of decades have resulted from dramatic expansions in manufacturing industries. Also, in the recent past globalisation of manufacturing of increasing number of products has forced many multinational companies to establish manufacturing plants in these countries in order to lower production costs and remain competitive on international markets. Universities from USA, UK, Australia have

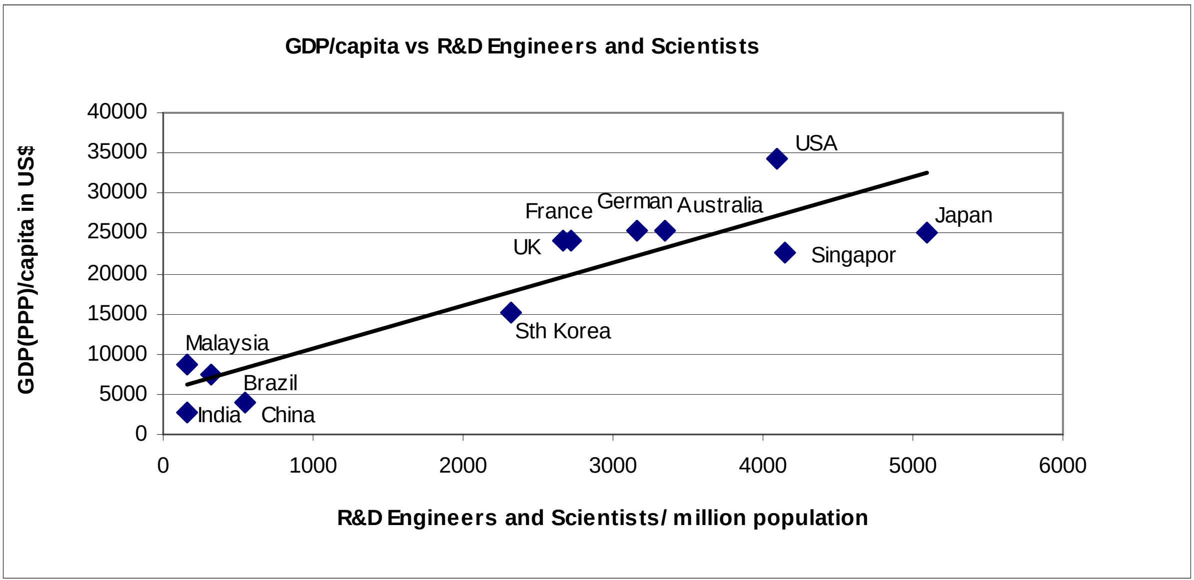

Figure 1. R&D engineers and scientists versus GDP for selected countries[3].

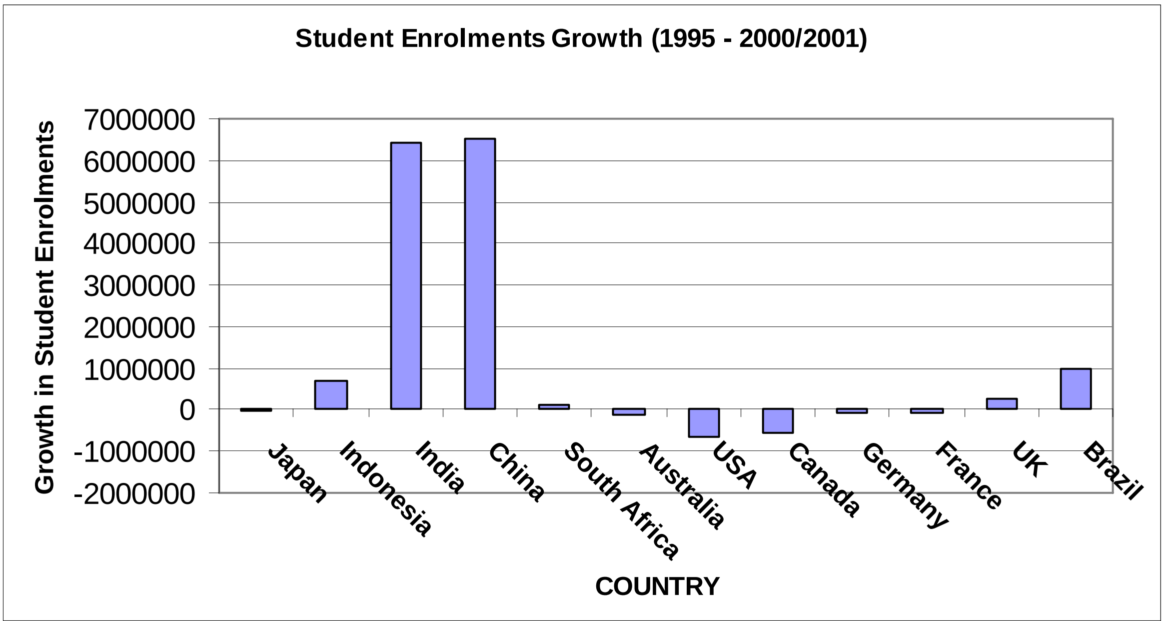

Figure 2. Student enrolments growth for selected countries[4].

made significant inroads in meeting the additional demand of engineers for such expanded manufacturing sector and infrastructure support in these Asian countries, by international delivery of some of their engineering programs[5,6]. International students enrolled in the universities of major countries providing English medium tertiary education are presented in Figure 3. Advances in computer information systems have now made available techniques, which can be employed for international delivery of education to a large number of venues or individual students in several cities simultaneously. Online engineering education (BE and ME) now available can be secured by anyone, anywhere from any institution or consortia of institutions[7]. This paper suggests the global delivery of engineering education via a virtual university as an economical and technically viable method provided sufficient planning and ironing of transnational issues precedes any such project for a successful outcome.

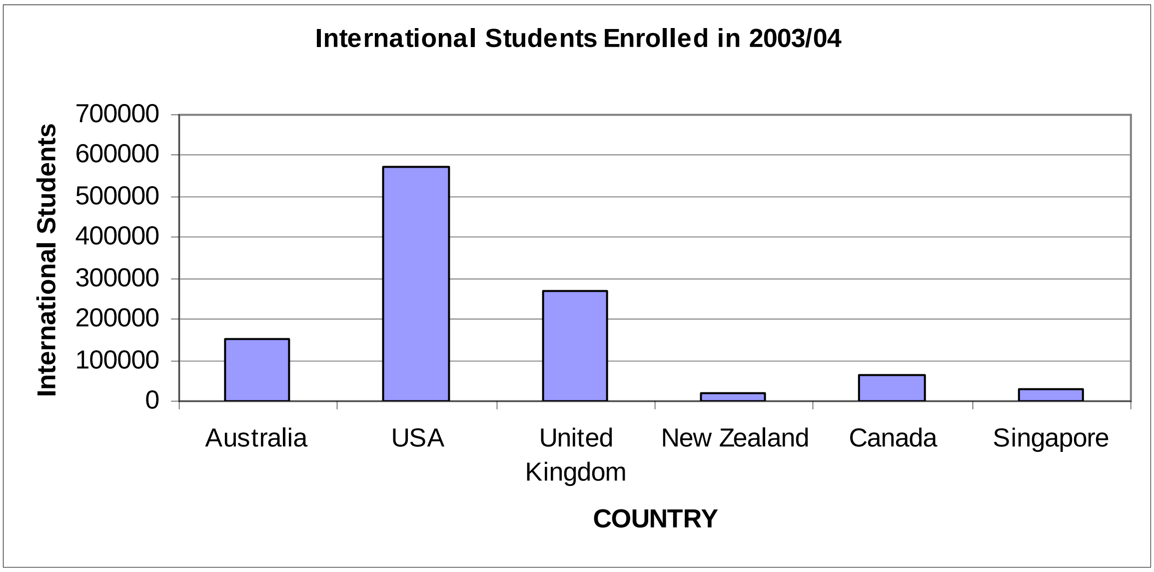

Figure 3. International students enrolled in selected countries providing English medium tertiary education[8].

Global Overview Of Engineering Education Systems

Education systems available currently for engineering students vary from university to university and country to country. These education systems evolved mainly after World War 2, when many countries became independent and felt the urgent need to educate their workforce, establish and expand engineering education infrastructure and start as many industries as possible to cater for the local demand of products and generate jobs. In Asia particularly Japan, India, China and South Korea, an undergraduate degree in engineering requires on an average about 4 years. If the entry to the undergraduate program is done after an associate degree or diploma from a technical or polytechnic college, then the duration of study for BE degree ranges from 2 to 3 years. Student learning occurs via lectures, tutorials, laboratory experiments, minor research projects and industrial experience or exposure. Postgraduate degrees such as Master of Engineering or a Doctor of Philosophy in engineering would require a further 1-2 years or 3-4 years further study and research respectively.

In Europe an undergraduate degree in engineering requires about 4 to 5 years full time study. An associate degree or diploma in engineering would need about 3 years full time study after High School. In Germany a degree program in engineering known as Diploma Engineer demands 9 semesters of full time study[9]. The program is divided into three stages namely the basic studies, the main studies and thesis research. In basic studies which lasts four semesters, the students are introduced to basic principles of the broad discipline in which they are studying. The main studies which also lasts 4 semesters allows specialization in a special field related to that discipline. One semester beyond that is provided for thesis project research and writing. A postgraduate degree such as Dr Ing would require another 4 years full time study and research. The engineering education systems of both Australia and England are very similar. Apart from engineering diplomas from TAFE or polytechnic colleges, the universities in both countries offer degree programs in various engineering disciplines which require about 4 years full time study. ME degree in engineering require another 1 year or 2 years full time study and research.

In North America and particularly in USA two types of undergraduate degrees in engineering namely BE and BTech are offered in the various disciplines[10]. A clear distinction between these two types of degrees is illustrated in Figures 4 and 5. Postgraduate programs such as ME and PhD are a combination of coursework and a research thesis and generally require about 1 and 3 years full time study and research respectively. A relative comparison of time span of Engineering Education Programs in several countries is presented in Table 1.

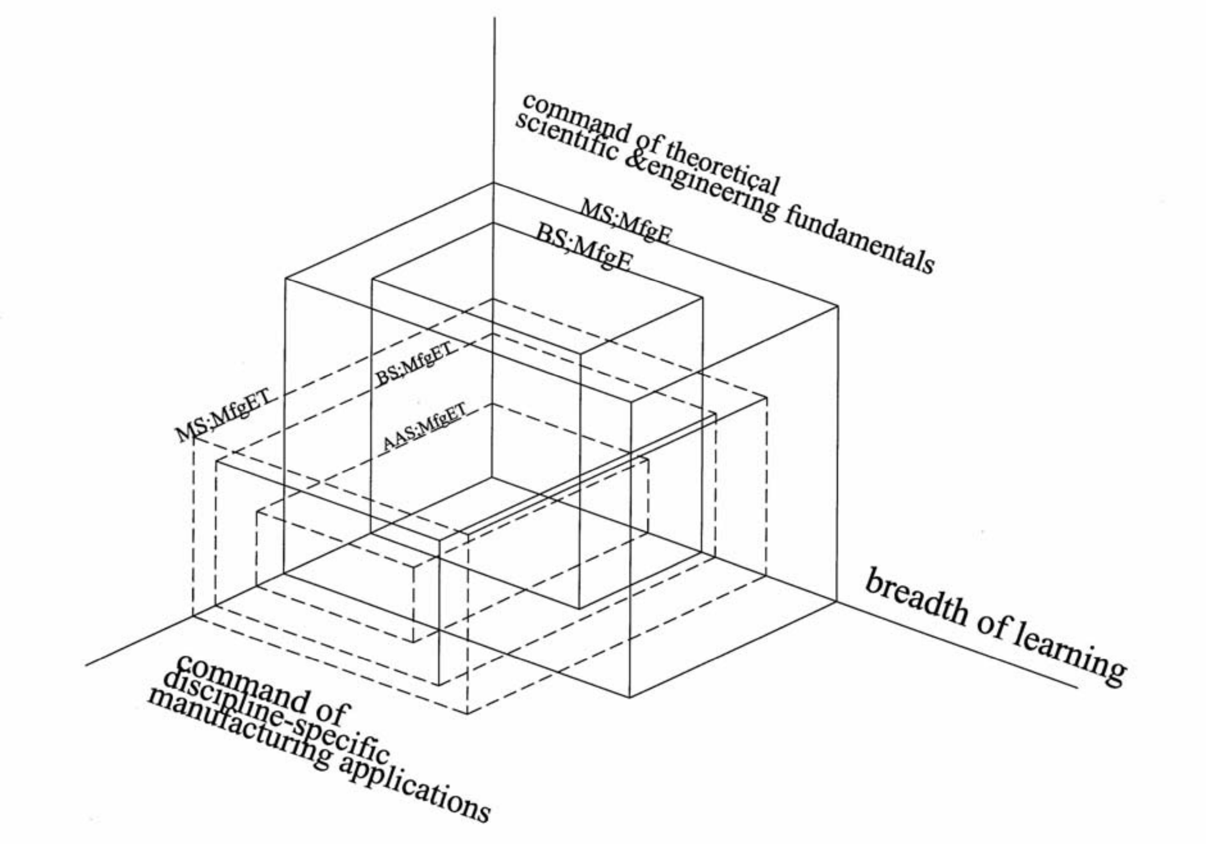

Figure 4. Learning objective coordinates for Bachelor of Science in Manufacturing[10].

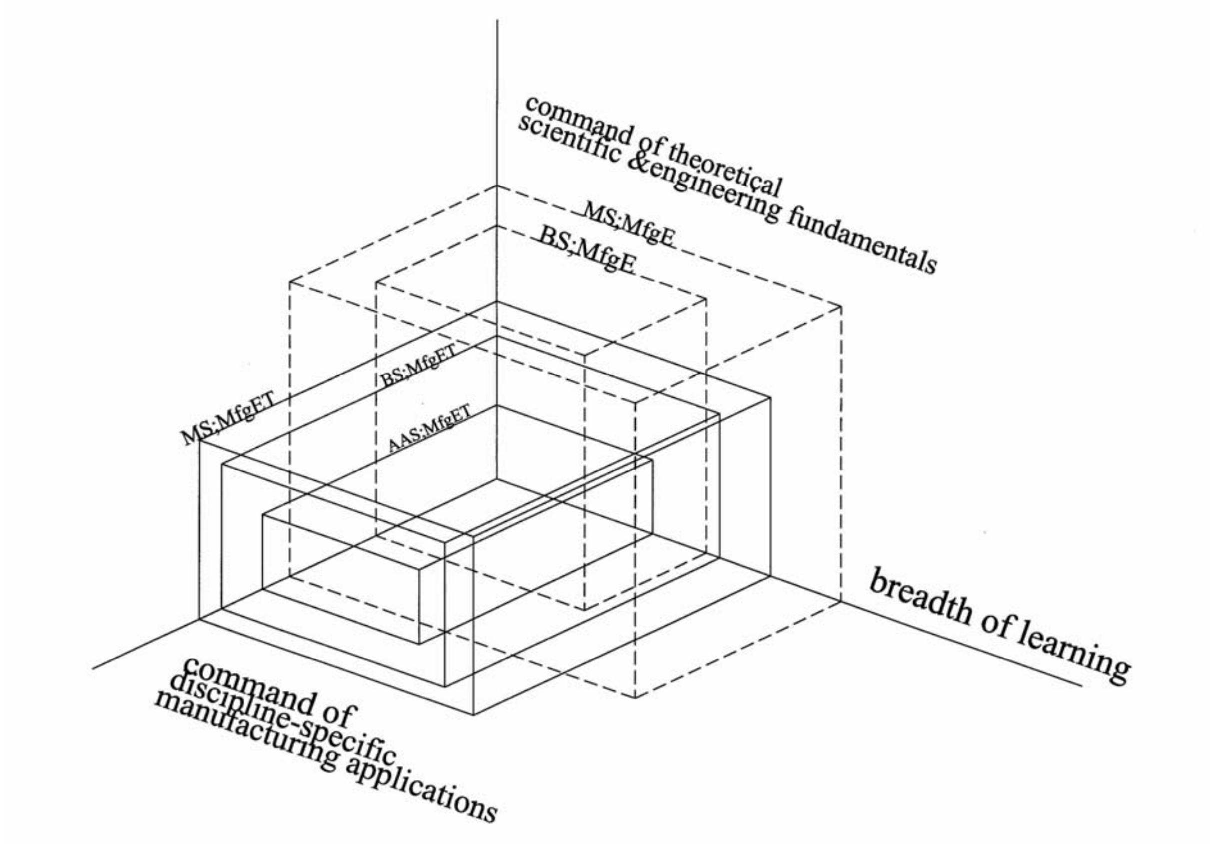

Figure 5 Learning objective coordinates for Bachelor of Science in Manufacturing Engineering Technology [10].

Table 1 Years required to complete various stages for an engineering degree

Country	Pre-Primary	Primary + High School	BE (Hons)	ME (Hons)	PhD
Australia	2 years	12 years	4 years	1 year	3 or more years
Canada	1-2 years	12 years	4 years	1-2 years	2 or more years
China	2 years	11-12 years	4 years	2.5 years	3 or more years
Germany	1-2 years voluntary	Primary + Gymnasium 12 years	→	≈ 5 years	3 or more years
England	1-2 years voluntary	12 years	3-4 years	1 year	3 or more years
India	2 years	12 years	4 years	2 years	3 or more years
New Zealand	2 years	12 years	4 years	1 year	3 or more years
USA	2 years	12 years	4-5 years	2 years	2-3 years

During the past few decades there has been a significant quantitative and qualitative expansion of engineering education. Though the developed countries have produced additional engineering graduates in order to cater for the demand from research and development of new technology and products as well as the industries, the major expansion in engineering education/or engineering graduates comes from the developing countries particularly those with high growth in GDP. College age population including natural science and engineering degree holders for selected Asian countries is presented in Figure 6.

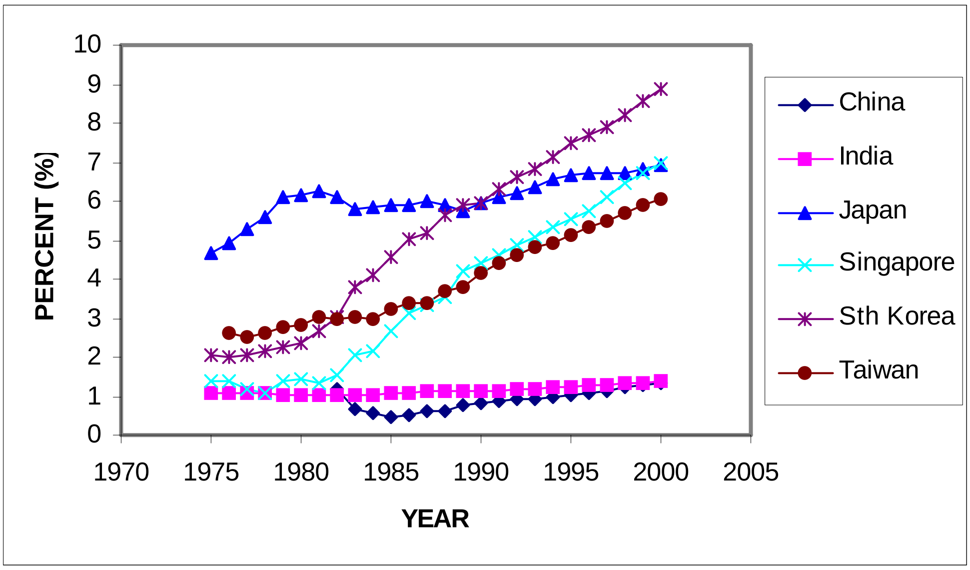

Figure 6. College age population holding science or engineering degrees[4,11].

Global Delivery

An ideal learning environment should contain staff-student interaction, student-student interaction and ready access to libraries or databases relevant to the topic or the subject taught. Apart from providing such an environment, the aim of any distance education[12] is to overcome the geographical distance and time constraints, offer interactivity, efficiency, on-demand access, low cost and allow students to learn in their own chosen time at the venue they like. The advancement of technology and computer information systems have made it possible to employ several new modes of delivery for distance education. Included among these are world wide web or internet based delivery, computer conferencing, video conferencing, voice mail, teleconferencing and terrestrial delivery modes. Each mode has its benefits and limitations. Table 2 presents a relative comparison of these various modes which can also be employed for distance delivery of engineering education. A single method of global delivery can lower the cost of distance duration delivery. However, the increasing competition and demands for better quality of education have resulted in added emphasis on greater staff-student interaction - only possible if several types of modes are simultaneously employed for delivery of material to the students and vice-versa. A multi-media format which a virtual university can use for course delivery needs to have a combination of at least the following delivery modes.

- Internet/Web based delivery
- Video conferencing

- Limited print based material

Table 2 Comparison of various distance delivery modes of engineering education

Mode	Cost	Time to Deliver	Affordability
Internet	Medium	Short - minutes/seconds	Developed countries - all students Developing countries – high income group only
Web CT	Medium	Short – seconds/minutes	Same as above
Television	High	Medium	Same as above
Radio	Medium	Medium	All students
Video + Print Based Material	Medium	Long – days/week	Developed countries - all students Developing countries – high & medium income groups only
Audio + Print Based Material	Low	Long – days/week	All students
Print Based Material Only	Low	Long – days/week	All students

Transnational Issues

With the attempts towards globalization of education gaining momentum, the transnational issues associated with engineering education have started gaining attention from both the management and academics from educational institutions as well as education departments of federal governments. Many developed countries like USA, UK, Canada and Australia are in a position to export educational services. On the other hand/side there is a large number of developing countries whose engineering education infrastructure is heavily overloaded in order to fully meet the demand of qualified technical personnel for expanding industries and other infrastructure such as transport, railways, power generation/transmission, communication etc. If the cost of the engineering education provided/exported by developed countries is low and affordable many developing countries may like to employ this mode of producing additional graduate engineers. However, education including engineering education falls under a banner of services whose export need to be governed by WTO regulations.

In order to successfully win collaborative engineering education projects and complete them without major hurdles, significant prepatory work, planning and discussions amongst both parties (exporter and importer) need to be carried out. Some pertinent factors which need to be considered in international delivery of engineering education via virtual university are listed/detailed/discussed as follows:

- Global delivery of engineering education via virtual university needs the support and enrolment of a large numbers of students from various countries. Hence the organisation or country owning such virtual universities must have agreements and approvals of relevant federal authorities from theses countries."

Such agreements include

- Agreements for enrolment of students, enrolment limits (maximum and minimum number of students) telecasting or electronic mailing of education material.
- Visa provision for the visits of personnel and custom clearance of any equipment purchased and supplied from overseas.
- Sharing of investments on infrastructure and fixed as well as movable assets.
- Sharing of copyrights of intellectual property, newly developed technology and patents granted, books and course material etc.
- Sharing of income and profits.

Cross-Cultural Aspects

Smooth cross-cultural communication amongst management and administrative personnel, academic, research, demonstration and general staff as well as the students is a key aspect for the successful operation of a virtual university. Cultural or religious sensitivities should be kept in mind and every effort should be made not to offend colleagues or students as regards to their religion, culture or race. In order to impart such cross-cultural communication skills to the engineers who want to work on international assignments, a number of researchers[13,14,15] have emphasized inclusion of subjects based on various cultures, in postgraduate programs in engineering at universities.

Resource Requirements

The methodology or the way for creation of virtual university has been detailed in a number of recent publications[7,16,17]. However, when such virtual universities are employed to deliver engineering education to a large number of international locations, the resource requirements and their integration need to be well planned. A variety of resources are required for establishment and successful operation of a virtual university. These resources include:

- Fixed as well as movable assets such as land, buildings for VU office, limited number of lecture rooms, laboratories, workshops, associated equipment and machinery.
- Central computing centre and network.
- Regional/country servers for serving notes, lecture material, reading material and library needs (Figure 7).

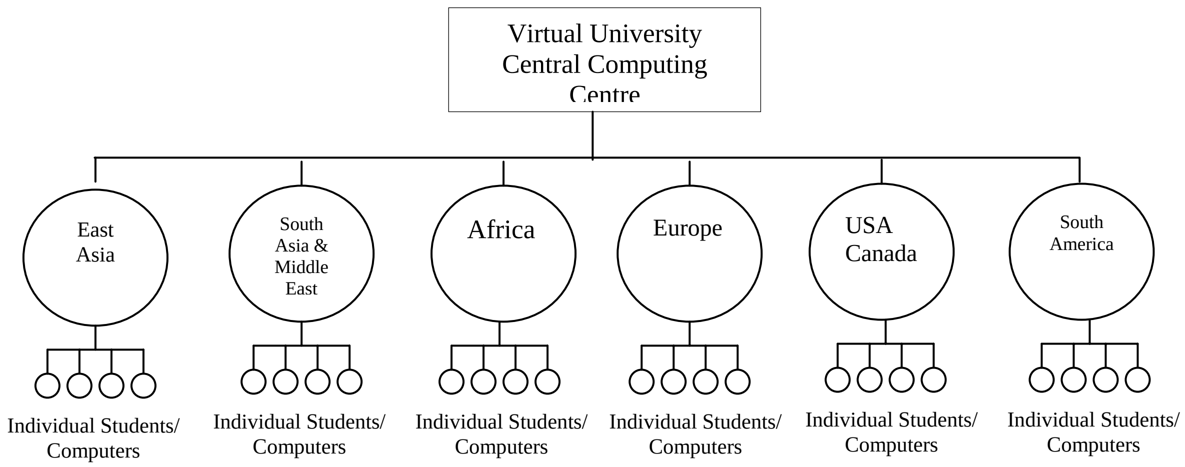

Figure 7. Computing resources architecture.

- Computing hardware and software personnel for operation and maintenance of central as well as regional computers and servers
- Electronic library, librarian and associate staff.
- Management and administrative personnel.
- Academic, research, demonstration, technical and general staff.
- Videoconferencing facilities and WebCT support.
- Operating capital.

This is not an exhaustive list of resources required for operation of a virtual university involved in global delivery of engineering education. Many more resource items can be added. However, it contains most of the resource items that are necessary for establishing and operating a virtual university.

Conclusions

Increasing globalization of education and resultant competition for recruitment of students will force educational institutions to develop delivery modes which are cost effective and technologically feasible. This paper first presents an overview of engineering education in selected countries of the world and then suggests the use of virtual university as a global provider of engineering education and discusses the pertinent transnational factors which can significantly contribute in the success of such initiatives.

- There is a significant unmet demand of engineering education in a number of regions of the world.
- Delivery of engineering education via virtual university to the students in these regions is a mode which can be effectively employed provided the costs and technology are brought in the reach of large number of students both in developing and developed countries.
- The curriculum design and development must be carried out in order to cater for the needs of engineering students from various regions where educational standards may vary significantly. Such a task will be a huge challenge. However, with some innovative ideas, a curriculum design recognised by relevant authorised educational bodies of the various countries is achievable.
- In order to succeed, the contracts between exporting and importing countries for global delivery of education must be based on win-win situation.

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