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Colombia & the New Global Economy: Implications of Tratado de Libre Comercio for Colombian Industry, Engineers and Engineering Educators[1]

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ABSTRACT The landscape of the world economy has changed significantly over the last twenty five years. The inter-connectedness of national economies, the rapid ascent of the BRIC countries (Brazil, Russia, India, China) in the global engineering environment and the pro-active role of organizations such as the World Trade Organization, regional alliances such as the EU, and Mercosur are factors that have synergized this movement towards a new order. The completion of the Tratado de Libre Comercio (TLC) agreement is a major milestone for the Colombian economy. These developments have serious and opportunistic implications for organizations, engineers, and engineering educators. We focus here on the drivers and consequences for engineering practitioners and educators. Corporate strategies, along with the need for engineering curriculum reform to ensure that Colombian engineers will effectively compete in the global marketplace, are detailed.

1 Note: this paper is adapted from talks presented to the Universidad de Los Andes and Universidad Industrial Santander in August 2006, and from a paper titled, *The New Global Economy: Implications for Manufacturing Engineers and Educators* by Bopaya Bidanda, Ozlem Arisoy, Larry J. Shuman, Tehran International Congress on Manufacturing Engineering, Tehran, Iran, December 2005.

THE GLOBAL ECONOMY

Globalization is a broad term that summarizes the increase in world trade as well as the borderless worldwide interdependencies in the framework of socio-political and economic relationships. The integration of the global economy through trade has given rise to the interconnectedness of international economies and politics. Decisions and activities in one part of the world can no longer stay local; their effects ripple through the societies and economies of communities in different parts of the globe.

Table 1 provides evidence of the significant growth in economic interaction during the last decade. The growth in trade is a result of both technological developments and concerted efforts to reduce trade barriers. First, the trade liberalization enabled the expansion of international relationships. Since 1947, when the General Agreement on Tariffs and Trade (GATT) was created, the world trading system has benefited from eight rounds of multilateral trade liberalization, as well as from unilateral and regional liberalization. The last of these eight rounds (the so-called "Uruguay Round" completed in 1994) led to the establishment of the World Trade Organization to help administer the growing body of multilateral trade agreements [2]. Newer organizations, such as the European Union and the Mercosur, have accelerated the growth of today's inter-connected economy.

HS TOTAL ALL MERCHANDISE: IN THOUSANDS ($ USD)						
PARTNER	1993	1994	1995	1996	1997	1998
Total Exports (world total)	464,858,127	512,415,609	583,030,524	622,827,063	687,597,999	680,474,248
Total Imports (world total)	580,468,670	663,830,137	743,505,251	791,314,697	870,212,682	913,884,886
PARTNER	1999	2000	2001	2002	2003	2004
Total Exports (world total)	692,820,620	780,418,628	731,025,906	693,257,300	723,743,177	817,935,849
Total Imports (world total)	1,024,765,969	1,216,887,535	1,141,959,125	1,163,548,552	1,259,395,643	1,469,670,757

Table 1: International Trade 1993-2004 [1]

The impact of globalization is significant on the Colombian economy. This impact gave rise to major trade reforms accompanied by modifications of labor regime and some reforms in the financial system. Table 2 shows the trends in Colombian trade policy since 1985. The first row shows the Trade Policy Index, which is a measure of trade barriers and accounts for tariff barriers, non-tariff barriers and other policy attitudes toward international trade. A larger index indicates a more open economy. On the other hand, Average Import Tariff is the average of tariff rates. The second row shows that the tariffs rates in Colombia declined sharply in the past 20 years. The third row points to the decrease in import tariff dispersion, which is a measure of the variance in tariffs among different goods. It can be seen from here that the Colombia's embrace of and entrance into the world economy has been slow but steady culminating in the TLC.

	1985	1990	1995	1999
Trade Policy Index	.21	.41	.52	.56
Average Import Tariff	83	23	13	12
Import Tariff Dispersion	28	14	5	6

Table 2: Colombian Trade Policy [3]

At the end of February 2006, the United States and Colombia signed the TLC- Free Trade Agreement. By this agreement, companies from the U.S. and other parts of the world can enter freely into the Colombian market. The Free Trade Agreement ensures free and new market access for both countries' industrial products and services [4]. Different arguments are proposed, some in favor of the free trade, some against the liberalization of economy. Gracia and Zuleta [5] performed a simulation analysis to examine the effects of TLC on the Colombian economy. Three conclusions are drawn from the simulation analysis: First, economic integration brings larger welfare and production for the economy created by the import goods price reduction. Second, the real exchange depreciates under all scenarios that imply Colombian tariffs elimination. Third, tariff revenues are reduced and new sources of revenues have to be created ideally by the expansion of the Colombian industrial sector. The authors analyze the advantages and disadvantages of TLC by comparing it to other bilateral agreements.

In spite of all the arguments for or against trade agreements, globalization has expanded. Beyond trade liberalization, the rapid development in the communication and transportation technologies has facilitated easy accessibility to distant locations by means of business practices. In the recent decade, evolutions in Internet and the World Wide Web have had an enormous effect on the communication technology; current advances, such as wireless networks and quantum computers, promise further significant progress.

IMPLICATIONS IN THE CORPORATE WORLD

In order to remain globally competitive in an open economy in the long term, organizations must transform themselves [6]. The following steps are presented both as a proposed methodology as well as sample measures necessary to evaluate such a transformation.

ESTABLISH PERFORMANCE PARAMETERS.

The three universal parameters that can be utilized to evaluate an organization are: quality, cost, and time. Quality can be broadly defined as the extent to which a manufactured product meets its expectations. This can be translated as the percentage of products (or services) that meet customer expectations. While it would appear that establishing the cost of a product (manufactured or sold) would be relatively easy to establish, traditional accounting systems with standard overhead allocations often obfuscate individual product costs in factories or warehouses with multiple product lines. Tools such as Activity Based Costing can help alleviate this problem and establish the true costs. For example, the throughput time in a factory has traditionally been defined as the time between the arrival of raw materials and the shipment of the product from the factory. This scope has now been expanded as the time between when a customer order is placed and the organization receives payment for the product. A single performance metric obviously cannot capture the multi-dimensional goals of an organization. The three metrics described above are correlated, often in counter-intuitive relationships. For example, one would assume that as organizations strive for higher quality, costs would rise proportionally. However, this is often not the case. Initiatives that improve quality often reduce waste and scrap, thus reducing cost. Reducing the throughput or 'lead time' of a product often leads to reduced costs of storage, lost product, reduced handling, etc., and improved quality (less machine down-time, efficient inspection processes, less waste, etc.). It is critical for organizations to establish strategic performance metrics that must be filtered down and expanded into departmental goals and metrics.

FOCUS ON 'KAIZEN' (THE PROCESS OF CONTINUOUS IMPROVEMENT).

This will enhance the acceptance of initiatives that will improve each aspect of the service or product lifecycle. This translates to a move away from thinking of oneself as a *service or manufacturing* organization, towards an organization that focuses on life-cycle management that encompasses the time between the initial service request and the final service delivery. In the case of a manufacturing organization, it would include product conceptualization, detail design, manufacture, distribution, maintenance, and recycling. This move integrates the processes of Enterprise Resource Planning, Product Data Management, Document and Knowledge Management, Collaboration and Process Management, Total Quality Management, Customer Relationship Management, Supplier Relationship Management, and Environment, Health and Safety Management.

Even organizations that are currently efficient, but complacent in their efforts to improve productivity as an on-going process, will find themselves inefficient and outdated in just a few years. Most organizations (as part of their strategic planning), establish goals for continued growth. From an engineering perspective, establishing quantitative productivity goals are at least as important.

CLEARLY IDENTIFY YOUR SUPPLY CHAIN/NETWORK.

In the new global economy, competitiveness goes beyond efficient factories that best each other in the pursuit of expanded markets and sales as follows: Entire supply chains now compete against each other since the strength of a chain is determined by its weakest (or most inefficient) link. The large majority of today's products are manufactured by a series of factories and logistical moves before it reaches a consumer. Depending on the organization, typical elements of a supply chain include transportation mode (shipping, rail, air, etc), warehousing, distribution, packaging, return goods handling, salvage and scrap, auditing, etc. A significant component (30% and over) of overall cost can be absorbed by these activities.

Supply Chains can be considered to have three major elements as follows:

Information: Includes the different technical and process aspects of managing information flow through the supply chain in an efficient and timely manner.

Infrastructure: Comprises the physical elements of the supply network that move products across the supply chain to include material handling equipment, facilities, and transportation equipment.

Relationships: The focus here is on the human relationships in the supply chain. This is probably the least understood (and often the weakest) element in the chain. A break-down in this element (say concealing information of a possible union strike in a factory) is likely to have a major negative impact on the rest of the supply chain. It is critical that each organization carefully analyze their supply chain(s) to identify strengths, weaknesses, and bottlenecks.

THINK GLOBAL. ACT LOCAL.

Successful organizations tend to think globally in terms of their market but decentralize decision making so that local strengths, weaknesses, and -most importantly- customer needs are satisfied. For example, Toyota has followed a widely successful formula where "it assembles cars in and near local markets, provides jobs and making the products less foreign"[7]. In an implementation of this strategy, Toyota developed an innovative, international, multipurpose vehicle (IMV) platform or chassis that can be manufactured in locations that are specifically targeted to leverage the advantages of inexpensive labor and free trade zones. This strategy appears to have worked well for the organization where overall sales have increased steadily over the last 5 years. Hindustan Lever (the Indian Division of Unilever) has adapted this 'Act Local. Think Global' strategy to its advantage. When sales were flat, the organization chose to identify new markets to grow and chose to focus on lower income Indians [8]. Hindustan Lever's research laboratory developed a low cost soap that could be used both to wash clothes and to take a bath. This successful product was then marketed and exported to other parts of the world that faced similar challenges including limited water and electricity (such as Congo). ABB implemented an internal intra-net based strategy that allowed local ideas for new products and projects to quickly reach decision makers in Switzerland [9].

IMPLICATIONS FOR ENGINEERS.

In the new global economy, the practice of engineering can often be considered as a 'fee for service' operation. It would appear that while companies will always require that they retain key technologies and core competencies, traditional and routine engineering tasks will continue to migrate to lower cost countries. This would lead us to believe that the 'next generation' of engineers may need skills different from current engineers. Also, engineers may need to align their focus with economic development and their home country's niche in the global economy. For example, engineers educated in China will need to focus on mass production techniques, while engineers in Japan may focus on manufacturing product design and automation and while Colombian engineers may need to focus on service engineering and automation in coffee picking and processing.

Another consequence of globalization may be a differentiation in both the job market and education of future engineers. While the manufacturing engineer today is expected to have a high level of technical skills and analytical ability, the next generation of manufacturing engineers may also want to focus on project management and systems integration. Table 3 presents the shift in required manufacturing engineering skills across generations. The prolific production of engineers in both India and China (in excess of 350,000 engineers a year) will have a definitive and lasting impact on global work migration.

Table 4 describes the number and percentage of graduates in six major countries. Most South American countries graduate a lower percentage of engineers than China, Russia, Japan, and South Korea. It is imperative that pro-active steps are taken to attract the best and the brightest to engineering.

Traditional engineering education no longer meets the needs of the 21st century engineer. While the technical skills and an analytical mind are still required, they are no longer sufficient for a competitive global engineer. Engineering graduates of the newly developed countries are often as talented technically as their western colleagues. Therefore, engineers in the more developed countries need to have different skills in order to compete with colleagues who demand only a third of or less of their salary [12]. The good news is that although the recent trend of outsourcing has moved some engineering jobs offshore, there will remain a strong demand for engineers who work closely with customers, manage research teams, and creatively improve business processes. Thus, engineering students must learn to become project managers and system

TRADITIONAL ENGINEERING ABILITIES	NEXT GENERATION ENGINEERING ABILITIES
Design	General planning
Planning, scheduling	Negotiating
Writing/implementing computer programs	Communication in different languages with different cultures
Core technical skills	Teamwork
Solve complex problems	Global awareness
Innovate	Work closely with customers and manage research teams for innovation

Table 3: Traditional vs. Next Generation Engineering Abilities [10]

COUNTRY	TOTAL DEGREES	TOTAL ENG&NAT SCIENCE	TOTAL ENG	PERCENT ENG& SCIENCE	PERCENT ENGINEERING	PERCENT FIRST DEGREE
China	440,935	255,158	195,354	57.87	44.30	2.2
USA	1,199,579	199,411	60,914	17.12	5.08	35.3
Russia	554,814	183,729	82,409	33.12	14.85	25.6
India	750,000	176,036	29,000	23.47	3.57	4.8
Japan	532,436	136,158	103,440	25.57	19.43	30.1
S.Korea	204,390	74,672	45,145	36.53	22.09	24.7

Table 4: Engineering and Science Graduation Numbers [11]

integrators. In addition, part of their education must be directed at learning about different cultures and acquiring the ability to work cross-culturally. These latter points are consistent with McGraw who argues that by redesigning education within the context of global economics, engineering schools can encourage innovation while still training highly technical graduates [13]. Engineers need to have personal, social, and cultural skills in order to be successful. Companies require engineers who are capable of navigating in and adapting to different cultures.

IMPLICATIONS FOR ENGINEERING EDUCATION

We suggest that one way to prepare for the future is through an international engineering experience. A relatively small but growing number of students now elect to partake in study abroad programs to gain cross-cultural skills and to learn to work with diverse populations. In addition, students are beginning to seek internships abroad in order to have the challenge of working in multi-cultural environments. A broader solution is to formally enhance the engineering curricula in response to the rapidly changing landscape of the global engineering environment. Engineering Schools across the world are recognizing the importance of international experience and have developed model programs. For example, Georgia Tech has proposed that 50% of its graduates have an international exposure. Worchester Polytechnic Institute (WPI), a proponent of ensuring a global context in the engineering curriculum, requires a substantial portion of its graduates having an international project experience [14]. Other examples will continue to appear as leading universities across the world do not see this as a problem, but recognize the opportunity to produce engineering leaders of the future.

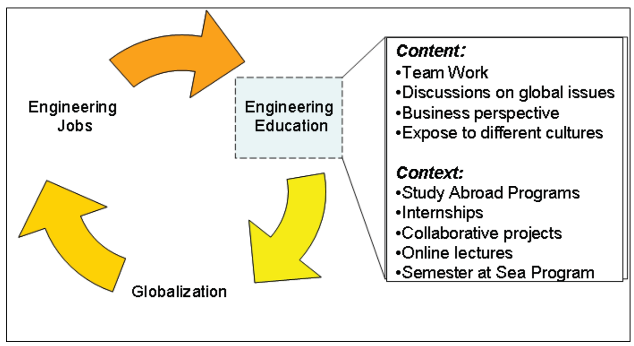

Figure 1. Consequences and Drivers of Engineering Education

One of the roles of engineering educators is to prepare the students to work in an economy that is increasingly global in nature [15]. This role can be achieved by adapting the engineering curricula so that graduating engineering students will be able to work and succeed in companies that are now considered to be transnational. The adaptation of engineering curricula to the global environment involves a systematic approach that can be applied in several ways. It is believed that leading and progressive engineering schools will continue to incorporate internationalization initiatives that expose the students to up-to-date global manufacturing problems. The methods and courses of actions are summarized in Figure 1 and will be briefly described in the next sections.

An increasing number of universities in the Americas, Europe, and Asia are creating programs that allow engineering students' exposure to international settings. Many universities collaborate to form strategic alliances in the form of 'twinning programs'. Others offer tuition exchange programs to their students that are based on a collaborative effort between the partner universities. Partner universities send an equal number of students as part of the exchange; under this model, students pay tuition directly to their home institution. This is an affordable way for students to live in a different environment and learn about a different culture. There are also a number of institutions and non-profit organizations to assist students who want to spend a semester or a year in a country of interest [16]. These programs are offered in a wide range of countries and in a variety of concentration areas. Students can spend up to two semesters in other accredited universities from all around the world and earn credits toward graduation. Of particular note is the Global Engineering Education Exchange Consortium (GE3), a 100+ member organizational that allows students to spend a semester or two at a partner institution [17].

International Internships offer especially substantive opportunities for students to have an international experience. Multiple organizations help students not only to find internships but also facilitate the visa process and the preparations for living internationally [18, 19]. Since it may not always be possible for an institution to give all of its students the opportunity to study abroad, an alternative is to integrate the classroom education into an international setting through collaboration with a partner university.

CONCLUSIONS

As globalization continues to grow, the internationalization of engineering curricula will occur in a greater number of universities. Globalization should be considered as an important evolution in each country's economy including the industrial and service sector. Although its effects may vary from region to region, overall it is changing the work and functions of engineers all around the world [20]. Engineering educational programs will continue to be challenged to keep up with these changes as they prepare students for the new environment that is becoming more 'flat' as the playing field is leveled.

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