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Innovation, Design, Entrepreneurship and Leadership: Challenges for Latin America to Be Competitive in the Global Economy

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ABSTRACT

Due to the rapid changes in the social conditions due to the globalization process and the new challenges of the 21st century, it is very important to understand all the variables affecting the global economy and identify the strategic model to be competitive and contribute to the growth of the Latin American countries. This new model is calling for technological improvement to enhance the productive capacity and reach new markets. Therefore, it is very important to prepare the human capital capable for not only enabling the technological transformation but also creating new industries for economic development and competitiveness. This paper describes how design, innovation, entrepreneurship, and leadership are fundamental concepts that must be incorporated in the engineering curriculum in Latin America to educate the future engineers responsible for the changes needed to be competitive globally.

Keywords: Innovation, Design, Entrepreneurship, Leadership, Global Economy

1. INTRODUCTION

The establishment of new regional economic alliances beyond the frontiers of a single nation has required that engineers be prepared to work in an economy that is now best seen as essentially international in nature. Almost all major corporations now operate globally, and engineers are being challenged to design and develop, in a timely manner, new products that will impact a global market (Esparragoza and Devon, 2005). Due to this tendency, future engineers will be facing the new worldwide market where the barriers of the corporate world are disappearing. The global engineer must understand and accept diversity, be able to work in multi-national corporations, be able to work in multi-cultural teams, be able to propose solutions to problems impacting a wider and more diverse population, be able to communicate and socialize with people from different cultures, be able to use the technology to exchange ideas, solve problems and present solutions (Esparragoza, 2005). On the other hand, there is an increasing perception of the need for graduates of engineering to be creative thinkers and innovators from industry and professional associates (Forum on Creativity in Engineering Education). Additionally, it is evident that technology is a predominant force in transforming underdeveloped regions into prosperous and high tech areas (Lécuyer, 2001). The transformation of Silicon Valley can be cited as an example, as well as the technological revolution experienced by many Asian countries such as Singapore, China, Taiwan, Korea and Japan where the investment and development in technology has transformed the economy and lifestyle of those countries. Finally, in recent years, fostering entrepreneurship has become a topic of the highest priority in public policy throughout most industrial countries. This trend can be attributed to the growing awareness that new firms are a driving force of economic growth and job creation (Franke and Luthje, 2003). As a result, the engineering entrepreneurship has became popular in many academic institutions due to the necessity of training the student to combine the technical knowledge with the business background for product conceptualization, innovation and design, technical feasibility analysis, and market research and analysis (Sathianathan, 2002).

It is evident that there exists a common ground where the engineering design, the international experience, the creativity and innovation, and the engineering entrepreneurship melt together as fundamental foundations for the technology progress necessary for competiveness in the global market and economic development as depicted in Fig. 1. New financial models, where free trade agreements are being established in different regions, demand the formation of engineers with solid technical formation capable of working in cross-disciplinary and multinational teams. The new engineers for the Americas should be aware of the global nature of their profession, be versatile, creative and effective leaders to make the individual nations competitive and the new economic blocks sustainable and strong. This has been recognized in many developed countries and a great effort is being made to provide that formation for the new generation of engineers. Technology development is obtained mainly by investing in education and research to recruit and prepare the future engineers for discovering and implementing new advances in science and engineering. However, it has been observed that while universities in developed countries are teaching global design, engineering entrepreneurship, and forming alliances and consortiums to establish international collaborations, most of the educational institutions in Latin America and the Caribbean are behind in this type of initiative, with practically no engineering design and entrepreneurship courses, and few international projects. This lack of formation of Latin American and Caribbean engineers in the critical issues affecting the global market makes it difficult to generate a technology revolution in these countries, placing the whole region at a disadvantage compared to other regions.

The role of the educational institutions is to satisfy the needs of the communities and in particular of the productive sector in terms of human development and collaborative work. Mauricio Ramos (2000) in his article *Reflexiones sobre la vinculacion de la actividad cientifica y tecnologica con el sector productivo* calls for an alliance between the productive sector and the scientific and technological activities developed in universities and other research centers to enhance the competitiveness in global economies through research and service. This paper is related to the development of the human capital necessary to create the transformations and contribute to the enhancement of all the sectors that contribute to the economic growth.

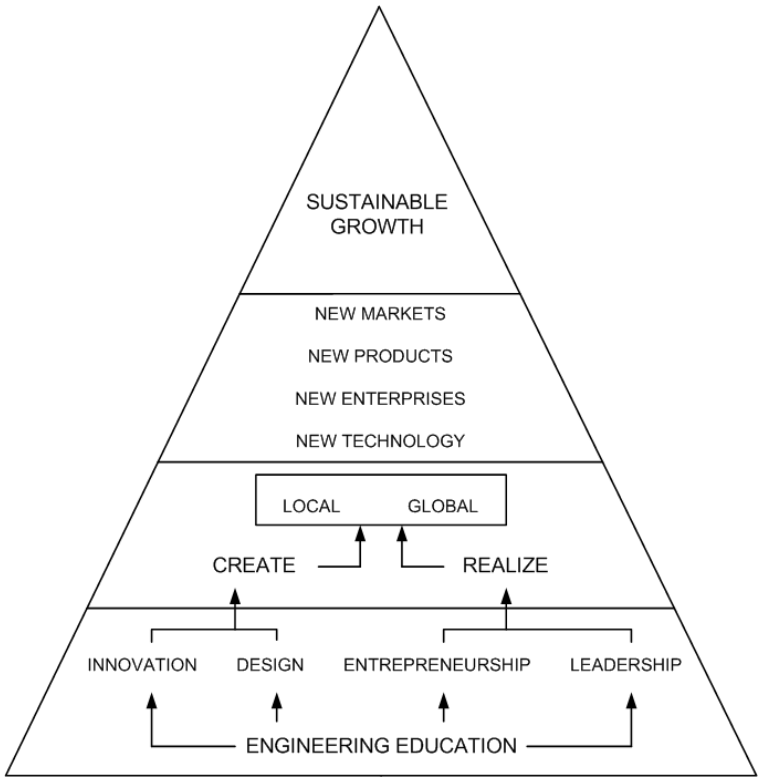

Figure 1: Engineering education pillar for the sustainable growth pyramid

2. GLOBAL ECONOMY

Globalization is a process that is transforming the social condition of the humankind and is characterized by the existence of global economic, political, cultural, and environmental connections that make the current borders irrelevant (Steger, 2003). Among all the dimensions of the globalization, the economic is probably the one that has devoted more interest. The World Bank defines globalization as the growing integration of economies and societies around the world, and the International Monetary Fund states that economic globalization is a historical process and is the result of human innovation and technological process. Based on those definitions, it is easily concluded that the engineers, as developers of technology, have played a fundamental role in the globalization process throughout the history, and have been actors of first order in what is known as modern globalization which has taken place after World War II (http://en.wikipedia.org/wiki/Globalization).

The process of integration of economies and societies as well as the rapid advances in technology are constantly changing the world's business environment. In the new economic systems, changes in technology drive as much as 85% of per capita income growth (Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, et al, 2007). Besides that, the innovative businesses are adopting new strategies to be competitive such as outsourcing, in-sourcing, and off-shoring. However, the development of knowledge-based economies is what should be highlighted here. In this model, the importance of intellectual power is manifest and educational success is critical. Hence, it is imperative to develop the human capital with the knowledge and skills to transform the local economies into ones with intellectual power to play a significant role in the global market. This implies an improvement not only in the quality of the education but also in the number of persons being educated.

3. CHALLENGES FOR LATIN AMERICA

It is evident that the process of globalization brings extraordinary challenges, especially for developing countries. The foreign competency is probably the biggest challenge. The Latin American and Caribbean countries do not have the technological infrastructure, a robust economy, and the human capital to compete with the developed countries. Besides that, the research and development culture is not strong putting the whole region behind in terms of scientific and/or technological development. However, the globalization phenomenon also brings opportunities. The markets become bigger and more diverse; there is more and easiest access to new technology; and the transfer of knowledge increases. All those elements contribute to enhance the living standards in underdeveloped regions.

The only way to take full advantage of the opportunities offered by globalization is to understand the challenges faced by the region and take actions to face them properly. One of the key elements to be competitive in the global market is to invest and enhance in engineering education. This will provide professionals capable of incrementing productivity through creativity, innovation and design. As a result, there will be an enhancement in infrastructure and technology. This trend will provide opportunities for the development of mid and small enterprises as part of the productive force. It is important to create a close circle by re-investing in engineering education to create a cycle of total quality improvement: improving education to improve productivity to develop new technologies to create new business.

The competitiveness indices summarized in Table 1 (World Economic Forum) clearly show the need of change in education particularly in higher education training, and technology readiness, and innovation. Only four out of 24 countries from Latin America and the Caribbean are in the top 50 in competitiveness for higher education and technology readiness, and only three for innovation. A more detail analysis of those indicators are summarized in Table 2. It is observed that the competitiveness indices reflect a poor performance for the region in all the areas with only few exceptions such as the high score of Barbados in internet users, of Brazil and Guyana in secondary education enrollment, and of Puerto Rico in the availability of engineers and scientists.

These indicators clearly show that there are some serious challenges ahead for the Latin American and Caribbean nations to be competitive. It is clear that there is a lack of human and infrastructure resources for innovation and business development. There should be a strong compromise from all the stakeholders to make the necessary

changes at all levels to face those challenges. These changes are calling for a synergy among the private sector, the government, and educational institutions to prepare the human capital, invest in infrastructure, research and development (R&D), and facilitate the establishment of new businesses for economic growth.

Table 1. Global Competitiveness Index for Latin American and Caribbean Countries 2008-2009

	ARG	BAR	BOL	BRA	CHI	COL	COR	DOR	ECU	ELS	GUA	GUY
Global Competitiveness Index 2008-2009	**88**	**47**	**118**	**64**	**28**	**74**	**59**	**98**	**104**	**79**	**84**	**115**
Subindex A: Basic Requirements	**89**	**33**	**108**	**96**	**36**	**77**	**63**	**99**	**90**	**66**	**84**	**115**
1st Pillar: Institutions	128	20	131	91	37	87	50	119	129	100	98	117
2nd Pillar: Infrastructure	87	24	126	78	30	80	94	81	108	56	71	98
3rd Pillar: Macroeconomic stability	64	114	77	122	14	88	85	78	16	62	87	133
4th Pillar: Health and primary education	61	10	93	79	73	67	37	106	92	86	99	62
Subindex B: Efficiency Enhancers	**81**	**56**	**128**	**51**	**30**	**70**	**60**	**90**	**117**	**84**	**86**	**112**
5th Pillar: Higher education and training	56	29	96	58	50	68	49	99	115	95	103	81
6th Pillar: Goods market efficiency	122	72	131	101	26	82	49	86	129	59	54	96
7th Pillar: Labor market efficiency	130	46	129	91	17	92	35	86	122	57	81	109
8th Pillar: Financial market sophistification	117	38	119	64	29	81	70	101	125	72	95	98
9th Pillar: Technological readiness	76	26	133	56	42	80	60	73	104	90	74	103
10th Pillar: Market size	24	127	87	10	47	37	78	72	61	81	74	129
Subindex C: Innovation and Sophistication factors	**81**	**51**	**134**	**42**	**44**	**60**	**39**	**86**	**118**	**96**	**65**	**111**
11th Pillar: Business sophistication	71	56	133	35	31	64	42	75	99	79	52	95
12th Pillar: Innovation	98	49	133	43	56	61	38	103	129	118	74	124

	HON	JAM	MX	NIC	PAN	PAR	PER	PUR	SUR	TRI	URU	VEN
Global Competitiveness Index 2008-2009	**82**	**86**	**60**	**120**	**58**	**124**	**83**	**41**	**103**	**92**	**75**	**105**
Subindex A: Basic Requirements	**78**	**97**	**60**	**122**	**54**	**123**	**94**	**44**	**73**	**65**	**57**	**111**
1st Pillar: Institutions	82	86	97	118	70	132	101	44	99	104	45	134
2nd Pillar: Infrastructure	75	67	68	128	55	130	110	31	99	63	69	109
3rd Pillar: Macroeconomic stability	89	130	48	123	55	113	67	81	32	51	104	110
4th Pillar: Health and primary education	83	77	65	98	64	85	95	38	63	72	54	74
Subindex B: Efficiency Enhancers	**91**	**75**	**55**	**116**	**67**	**111**	**69**	**38**	**127**	**80**	**83**	**94**
5th Pillar: Higher education and training	93	82	74	113	77	117	89	36	100	78	62	79
6th Pillar: Goods market efficiency	75	63	73	112	57	104	61	29	125	90	79	132
7th Pillar: Labor market efficiency	82	70	110	99	77	117	75	37	104	76	106	131
8th Pillar: Financial market sophistification	84	59	66	100	26	96	45	30	114	52	88	116
9th Pillar: Technological readiness	96	45	71	122	62	119	87	44	108	63	64	86
10th Pillar: Market size	84	98	11	108	85	93	50	68	130	103	91	36
Subindex C: Innovation and Sophistication factors	**89**	**72**	**70**	**124**	**58**	**132**	**83**	**26**	**117**	**79**	**82**	**116**
11th Pillar: Business sophistication	82	69	58	119	51	118	67	28	113	73	85	115
12th Pillar: Innovation	104	68	90	127	73	134	110	30	117	86	77	115

Table 2. Global Competitiveness Index for Latin American and Caribbean Countries 2008-2009: Some indicators in Education, Technology Readiness and Innovation.

	Education		Technological readiness		Innovation		
Country	Secondary enrollment	Tertiary enrollment	Internet users	Personal computers	Capacity for innovation	Company spending on R&D	Availability of scientists and engineers
Argentina (ARG)	75	22	60	66	79	81	81
Barbados (BAR)	18	57	1	51	77	59	61
Bolivia (BOL)	82	52	99	98	128	130	128
Brazil (BRA)	14	76	57	50	27	31	57
Chile (CHI)	54	41	51	53	57	64	35
Colombia (COL)	83	68	75	82	54	66	88
Costa Rica (COR)	71	78	49	39	43	30	46
Dominican Republic (DOR)	96	61	71	99	91	100	107
Ecuador (ECU)	97	92	82	59	116	125	125
El Salvador (ELS)	101	82	87	84	96	117	124
Guatemala (GUA)	105	107	86	103	65	60	90
Guyana (GUY)	15	100	55	91	100	90	130
Honduras (HON)	91	89	108	106	93	94	106
Jamaica (JAM)	68	84	27	73	81	58	97
Mexico (MEX)	68	84	63	55	67	71	105
Nicaragua (NIC)	99	87	115	93	127	132	123
Panama (PAN)	93	47	72	87	102	63	91
Paraguay (PAR)	98	75	113	69	129	131	131
Peru (PER)	46	58	56	61	86	80	103
Puerto Rico (PUR)	45	51	52	118	48	41	12
Suriname (SUR)	86	97	91	88	104	89	118
Trinidad and Tobago (TRI)	90	101	58	47	111	84	55
Uruguay (URU)	24	42	53	56	76	87	86
Venezuela (VEN)	87	35	74	65	113	106	102

4. ECONOMIC TRANSFORMATIONS

Technology is a predominant force in the transformation of underdeveloped regions into prosperous centers of high technology. Silicon Valley can be cited as an example of such a transformation. This region changed from an agricultural district in the 1920's into a high tech complex in the 1990's employing more than half a million engineers by year 2000. Similar transformations have occurred in Asia where the investments in research and development have transformed the economy and the living style of those countries.

Significant investments in science and technology during the 1990's in some Asian countries are paying back notable economic dividends in areas on high technology. The activities of research and development in Asia might have surpassed the European Union by 2002, and by 2003 was closed to be 10% higher. Based on this data, the investment of Asia in research and development might have reached approximately 80% of that one from the US. This can be reflected in the growth of China and other Asian countries (NSF Report, 2007).

Most of the technology companies are looking toward the Asian markets due to the rate of economic growth of those countries. A quick look at the rate of growth of the gross domestic product (GDP) shows that the first two countries are China and India.

Some countries in Asia have found they niche for economic growth. For example, India has become a leader in Information Technology (IT) and there are more than 500,000 IT professionals in India working on this field.

5. DEVELOPMENT OF HUMAN CAPITAL

The basic strategy for economic development is based on three pillars: new technology, leadership, and entrepreneurship. Therefore, engineers, technology and innovation are fundamentals elements for the sustainable growth of not only developed but also emergent economies. The changes in innovation and technology are the main long-term driving forces of the productive growth and the competitiveness in advanced economies. Additionally, high rates of entrepreneurship have a positive impact on innovation, productivity and competitiveness because new firms typically use a more efficient mix of labor, capital and technology than existing firms (National Competitiveness Council, 2005).

Innovation and developing knowledge are the main reasons for the accelerating pace of change in the global business environment according to the McKinsey Quarterly report of March 2006 (see Fig. 2). Besides that, a faster pace of technological innovation will have the highest impact on the profitability of the companies over the next five years according to the McKinsey Global Survey of April 2008 (see Fig. 3)

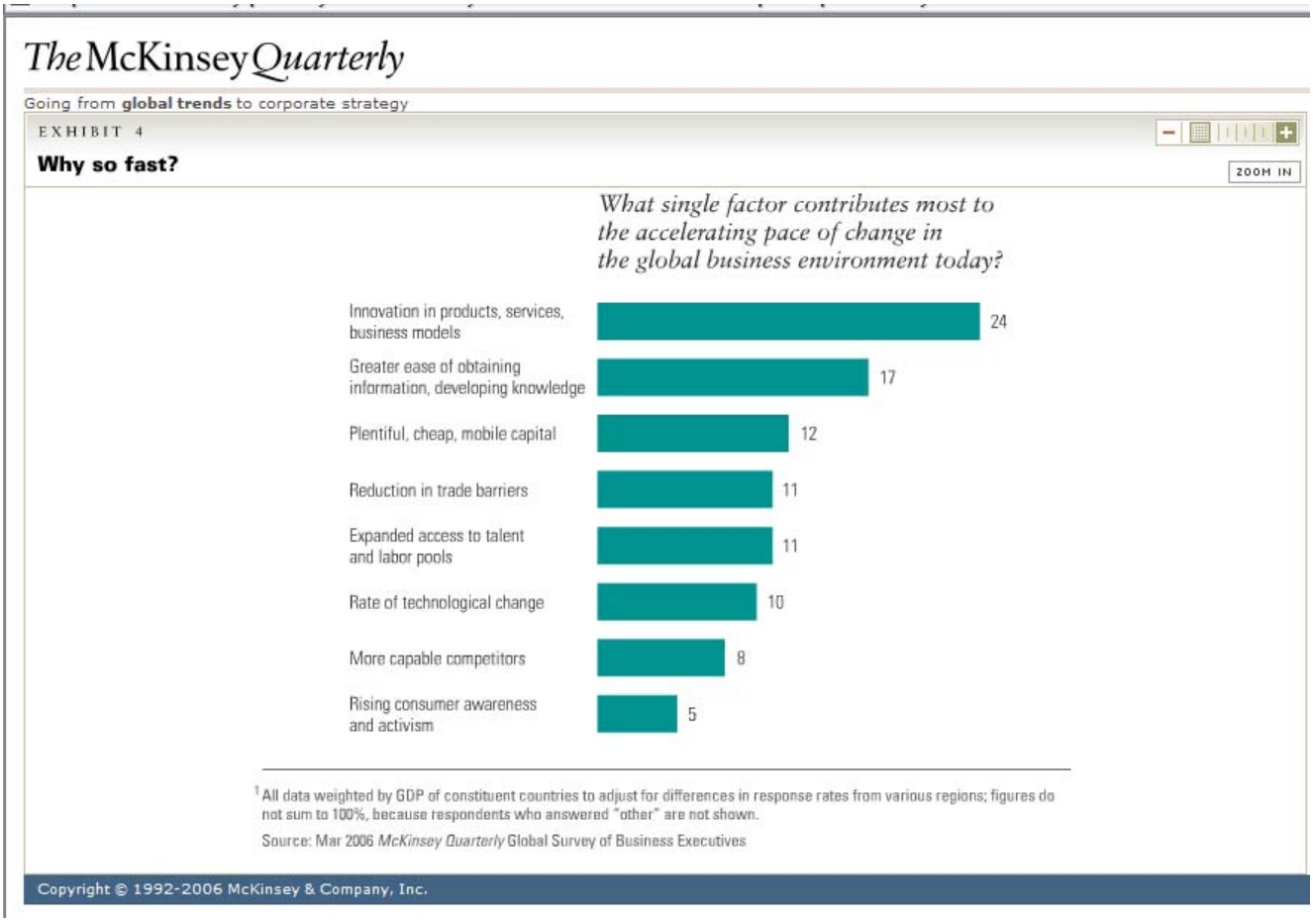

Figure 2. McKinsey Quarterly Global Survey of Business Executives March 2006

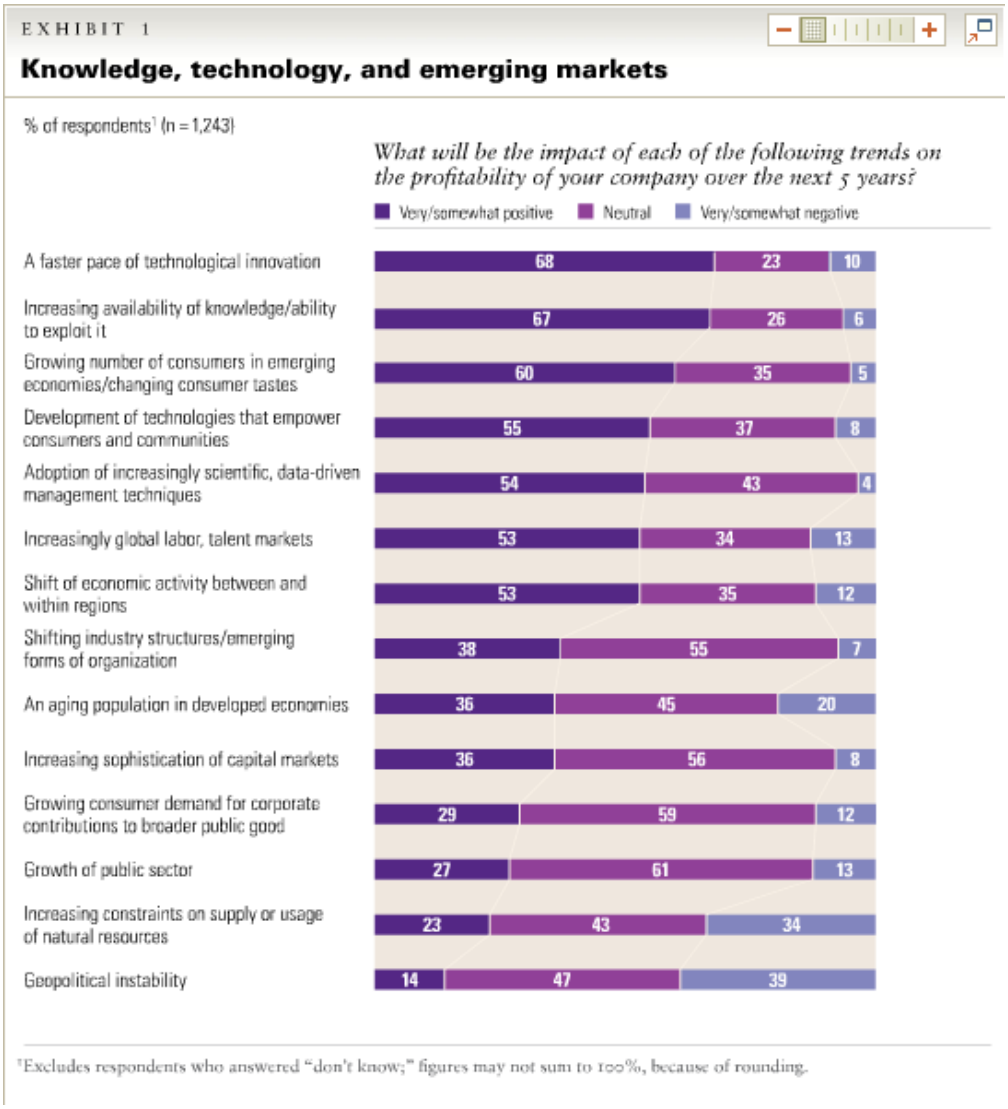

Figure 3. How Companies Act on Global Trends: A McKinsey Global Survey April 2008

It is evident that the great force behind economic transformations and sustainable growth is the technological development; but it is not only about investment in research and development but also about the development of the human capital capable of carrying out those transformations for the economic growth and competitiveness of the region. In that sense, engineers play a fundamental role economic growth of the regions. They not only solve local and global problems but also create and transfer knowledge. Thus, it is imperative that in educating the engineer for the new millennium, the technical know-how should be supplemented with professional skills such as creativity, business, teamwork and ethics among others. This requires changes in the educational model, investment in education, research centers, and infrastructure.

In order to properly develop the future engineers, it is important to understand what is needed to be competitive. According to the Business Dictionary (http://businessdictionary.com), competitiveness is defined as the ability of a firm or a nation to offer products and services that meet the quality standards of the local and world markets at prices that are competitive and provide adequate returns on the resources employed or consumed in producing them. Therefore, engineers should be trained to design innovative products and systems to satisfy local and global markets, and be able to realize and commercialize those products and services.

It is evident that the future engineer has to have a new set of attributes to be able to produce the changes locally and be competitive globally; an engineering that acts locally but thinks globally. The National Academy of Engineers (2004) identified the following characteristics for the engineer 2020:

- Strong analytical skills.
- Practical ingenuity - skill in planning, combining, and adapting.
- Creativity (invention, innovation, thinking outside the box, art).
- Communication.
- Business and management.
- Leadership.
- High ethical standards and professionalism.
- Dynamism, agility, resilience, and flexibility.
- Lifelong learners.

In addition to these attributes, a new engineer is a professional who (Esparragoza and Larrondo-Petrie, 2008):

- knows the fundamentals and dynamics of globalization;
- understands, accepts and appreciates diversity;
- is able to work in multinational corporations;
- is able to work in multicultural/multinational teams;
- is able to communicate and socialize with people of different cultures;
- is knowledgeable in other language;
- is able to use the technology for communication, exchange ideas and solve problems;
- is an entrepreneur;
- is an ambassador.

The new engineers require more than just the analytical knowledge and skills traditionally taught in an engineering program. Hence, the engineering curriculum should strengthen creative thinking, entrepreneurial and leadership skills, and ethical and professional behavior. It should also foster the teamwork and communication skills, and the understanding of the role of technology in the global economy and its ethical implications. Therefore, following content and concepts should be adopted in any engineering program:

Engineering Design and Innovation: the object of this topic is to study engineering design methodology, and the decision making approach concerning the creation and development of technical innovations using team design projects.

Engineering Entrepreneurship: the object of this topic is to study fundamental principles of entrepreneurship including the understanding and analysis of opportunities, designing of new products, development of a business plan, commercializing strategies.

Engineering Leadership: the object of this topic is to study leadership concepts, principles and theories through discussion and projects.

Collaborative Global Design Projects: Students participating in these projects work collaboratively with students geographically located in another country while solving an engineering design problem. These are usually short term projects that can be easily incorporated in the engineering curriculum as part of a course, especially in Engineering Design, or also as senior design projects or capstone projects

6. CONCLUSIONS

If technology is a key element for economic growth and design and innovation is a key element for technology development, then it is needed to educate engineers who enable the development of new technology by: promoting engineering design through the curriculum, fostering innovation, creativity, leadership and entrepreneurship, and facilitating the development of competencies and skills for the solution of local and global problems. Future engineers should be also educated with high ethical standards. They should be aware of his responsibility with the society and the environment, and their role in the technological changes and economic growth of the region.

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