Are STEM Programs Triggering Competitiveness?

An Exploratory Approach towards an Effective Talent Procurement

[1]Jesus David Argueta Moreno, [2]Taria Fabiola A. Ruiz, [3]Norma Carolina A. Moreno

[12]Faculty of Economics and Social Science
Universidad Nacional Autonoma de Honduras (UNAH), Honduras
jargueta@iies-unah.org, truiz@iies-unah.org
[3]Faculty of Actuarial Sciences, Universidad de Las Americas Puebla (UDLAP), Mexico
argueta.morenona@udlap.mx

Abstract:

American universities' reputation for excellence, advanced research and innovation attracts the best and brightest students from around the world, particularly the Latin American alumni. Parting from the fact, that they have the knowhow and thereby the potential to come up with an invention that could save thousands of lives or stimuli the growth of a whole new industry, one may infer that by the presence of these individuals on the US labor market may upgrade the countries global competitiveness.

By considering the previously mentioned the present study aims to evaluate the competitiveness potentialities offered by the foreign students to the US manufacturing sector and how this competitiveness levels are underestimated by the current Latin American governments and Higher Education Institutions (HEIs) that somehow "allow" the brain drainage phenomenon to expand.

Keywords: STEM Programs, Competitiveness, Manufacturing, Brain Drainage.

Investigations Main Objective:

The Determination of the Competitiveness rates boosted by the Foreign Student's enrolled on the STEM programs across the US Manufacturing Sector.

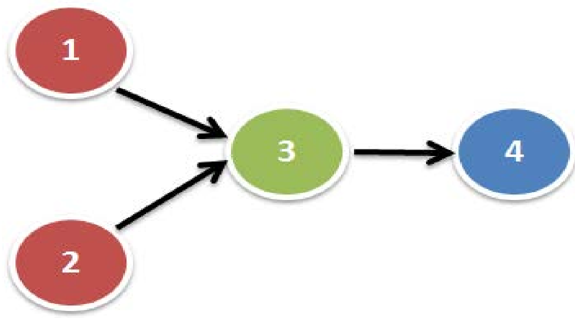
Investigations Secondary Objectives:

- A Contemporary Diagnose of the US STEM program Framework.
- The Identification of the current US HEIs and US government measures to retain the foreign STEM program undergraduate talents.
- The Determination of the US limitations towards the retention of the most talented Human Assets.
- The Determination of the US Manufacturing Sector Competitiveness

Variables in Study:

1. US Government Labor Market Conditions.
2. Global Brain Drainage Rates.
3. STEM Programs Best Practices.
4. US Manufacturing Sector Competitiveness

Figure No 1 Variable in Analysis



Source: Self Interpretation of the STEM analysis methodology

Variable Parameterization:

The variable parameterization process was undergone on this research, in order to limit the investigations scope, due to the significant range of analysis around each variable. On the other hand, this process aims to determine the core areas of evaluation during this study. The following tables depict the Variable Dimensioning procedure, where each variable fields or categorizations are determined.

The following tables portrait the different dimensions of each variable and present the areas/dimensions marked by the red oval. It is also worth mentioning that

Methodology:

The present investigation can be divided into 4 general research components:

One that Explores the theoretical inputs over the STEM programs performance and its relation with the brain drainage phenomena (contemplated on this research).

The Second that describes the impact of the variables defined as: “US Government Internationalization efforts” and “Latin American Brain Drainage Rates” over the “STEM Program Best Practices”, the third component, that procures the verification of the STEM Programs Best Practices stimuli over the competitiveness rates among the manufacturing sector and the fourth component which contemplates an instrument articulation between de RDCID, the DME and the Innovation Scoring, who is based on 5 main Key Performance indicators:

Awareness, Planning, Resources, Expertise and Processes.

Table No 1 The US Government Internationalization Variable Dimensioning

US Government International Efforts	US STEM Innovation Proposals
	STEM Innovation Networks
	STEM Teacher Pathways
	National STEM Master Teacher Corps
	Committee on STEM Education (CoSTEM)
	STEM to STEAM
	(STEM) Education Coalition Support
Latin American Brain Drainage Rates	Policy Regimes of Recipient Countries
	Higher levels of public expenditure
	The establishment of specific programs to attract skilled workers from developing countries
	GDP per Capita
STEM Best Practices	Kaufmann, Kraay and Matruzzi (KKM) Principles
	Barro & Lee STEM Indicators
	Burnside, C. and D. Dollar (2000). "Aid Policies and Growth"
	European Economic Review
	World Bank Policy Research STEM Working Papers
US Manufacturing Sector Competitiveness	Kaufmann, Kraay and Matruzzi (KKM) Index
	Research on Design Impact on Companies Performance, Brazil (RDICP - Brazil)
	Innovation Scoring
	Design Management Europe (DME 2010).

Source: Self Interpretation, of the "Dimensions of the US HEIs Internalization". STEM Education Coalition Internet Portal, 2014, http://www.stemedcoalition.org/

It is also worth mentioning that this investigation resembles a 5 step development process, on a sequence held as follows:

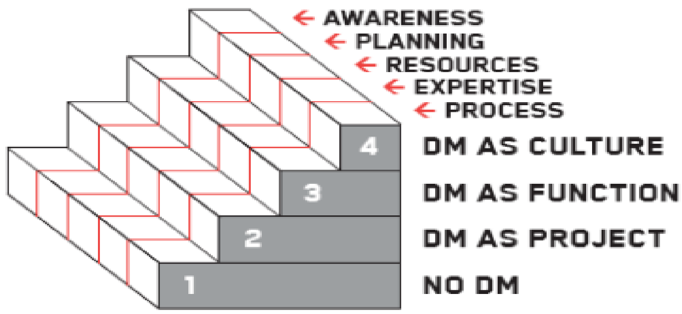
- The 1st stage requires an exploration of the theoretical background related to the STEM programs evolution, the US framework related to the STEM programs support and the current internationalization efforts.
- The 2nd stage requires an analysis over the incidence generated by the independent variables: US efforts towards the STEM Programs Evolution.
- The 3rd stage requires an analysis over the incidence generated by the STEM Programs Evolution and US Manufacturing Sector Competitiveness.
- The 4th stage demands the quantification of the competitiveness rate at which the STEM foreign professionals are boosting the US manufacturing Sectors productivity.
- The 5th stage, states the conclusions arrived through the data analysis process results.

It is worth mentioning that the variable parameterization procedures were helded in order to limit the scope of the analysis, since the magnitude of each variable presents a very extensive range. On the other hand the context in which the competitiveness rates were evaluated, contemplate the US Manufacturing Framework, due to the significant STEM program presence on the country's economy.

Where the competitiveness rates were evaluated with the use and articulation of the results from the analysis (referred on figure No 2):

- Design Management Europe (DME 2010).
- Research on Design Impact on Companies Performance, Getúlio Vargas Foundation, Brazil (RDICP - Brazil).
- Innovation Scoring, COTEC Portugal.

Figure No 2 The 5 Mayor Key Performance Indicators (KPI) on Sectorial Competitiveness Instrument Development



Source: Gomez Antonio, ¿How to Measure Design Contribution to the Competitiveness of Companies: Models for Analysis? Communication and Art Department University of Aveiro Portugal, 2011

Parting from the proper understanding of the common Key Performance Indicators (KPI´s) on each of the 3 instruments and their articulation, this research has holistically evaluated the US Sectorial Productivity.

Introduction:

During the past decades, the research and development, information technology and other science and technology related fields have skyrocketed in job demand and net worth. The demand for well-trained and educated doctors, researchers, developers, computer specialists and other similar jobs has increased dramatically, proportional to their salaries and benefits around the US labor market. Unfortunately, it seems that many American Higher Education Institutions (HEIs) and College Graduates get passed over for these highly competitive and highly paid jobs. One of the reasons often cited by companies for bringing in international talent is that U.S. high school and college graduates are not as proficient as their global counterparts in the science, technology, engineering and math (STEM) fields (Coggins, 1999).

Parting from the above, in accordance to the National Center for Education Statistics (NCES) analysis and interpretation, American school children are falling behind in the STEM fields. For instance in 2012, there were 29 nations whose high school students performed at a higher level of math than U.S. high school students, and 22 nations whose high school students performed at a higher level of science than U.S. high school students. As of 2013, only 44 % of U.S. high school graduates were ready for college level math, while only 36 % of U.S. high school graduates were ready for college level science (NCES, 2013).

It is worth mentioning that U.S. colleges and Higher Education Institutions (HEIs) are not immune to the STEM crisis either. As an example in the year 2008, 31 % of all U.S. bachelor's degrees were awarded in engineering and science fields, while other developed nations like Japan had a STEM proficiency of 61 % and China presented a 51 % rate on their bachelor's degrees awarded in science and engineering (NCES, 2013) . So by briefly describing the US STEM scenario, it is imperative for the US government to approach:

- The Most suitable local and foreign Human Capital Strategies, in order to obtain an optimal performance along the talent retention and procurement processes.
- The determination of the most suitable and accurate investment proportions, that effectively stimuli the conditions for a superior competitiveness pace on the manufacturing sectors.
- A flexible plan around the foreign STEM alumni working visa model.
- The quantification of the potential benefits generated by the STEM programs in the US, in terms of competitiveness enhancement.

US STEM programs Overall Diagnose:

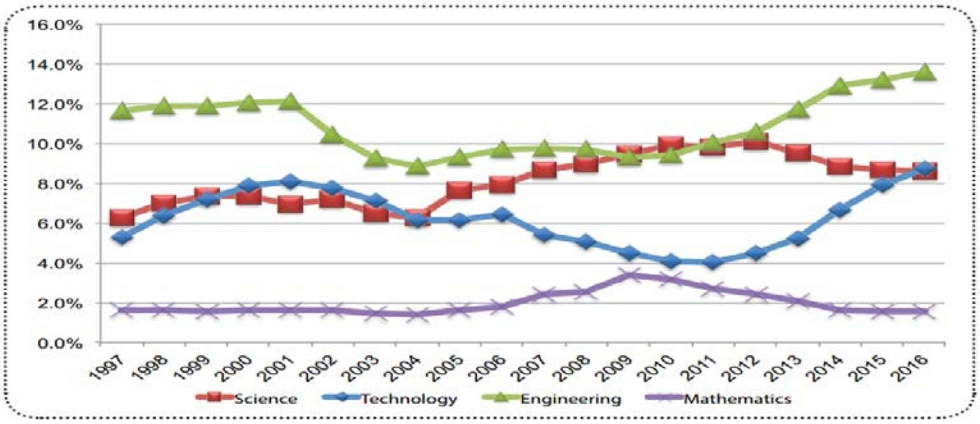
The United States has become one of the World's most powerful economies due to their significant efforts upon the procurement of its scientists, engineers and innovators. Yet today, that position is threatened as comparatively few US students pursue expertise in the fields of science, technology, engineering and mathematics (STEM) and yet there is an inadequate pipeline of skilled STEM teachers to cover this demands (NCES, 2013).

This research intends to provide a general overview of the US STEM context, in order to provide a general overview of the phenomenon in analysis, but in order to do so, one must be able to answer the following enquiries: *Where are the STEM Students? What are their Career Interests? and Where are the STEM Jobs?*

Where are the STEM Students? Since 2004, an overall interest in STEM majors and careers has grown among high school seniors in around 20%. Arguably the most concerning trend with students interested in STEM is the increasing gender-gap, were the female students express STEM interest at 14.5% compared to 39.6% for their male counterparts. Since 2011, interest in STEM has grown and is projected to continue rising for Asian, Hispanic, American Indian and White students, nonetheless the Southern region of the US has the highest concentration (36%) of students interested in STEM. (STEMconnector, 2012-2013).

What are their Career Interests? In 2012, Mechanical Engineering (20.4%) was the most popular major or career choice among STEM-interested students, while Biology was second at 11.9%. It is worth mentioning that the Engineering and Technology interest are on the rise, while interest in Science and Mathematics has decreased over the past few years (revise figure No 3).

Figure No 3 STEM Trends per Field



Source: Edie Fraser, 2012, "Where are the STEM Students?" My College Options & STEMconnector Report, 2012

Where are the STEM Jobs? US has the highest concentration (36%) of students interested in STEM. In 2012, the US STEM workforce surpassed 7.4 million workers and it is expected to grow significantly through 2018, to an estimated 8.65 million workers. Currently the manufacturing sector faces a large shortage of employees with STEM skills. Alarmingly, 600,000 manufacturing jobs are going unfilled in spite of current economic conditions. Between 2011 and 2015, an estimated 1.7 million jobs will be created in cloud computing in North America. Another noteworthy increase in STEM jobs has come courtesy of mobile application ("apps") technology, which has fostered 311,000 jobs in the "app economy." By 2018, the bulk of STEM jobs will be in Computing (71%) followed by Traditional Engineering (16%), Physical Sciences (7%), Life Sciences (4%) and Mathematics (2%).

Global Brain Drainage Tendencies:

The Brain Drainage singularities have induced several anomalies upon the Latin American and US labor markets, were several scientist have pursuit in vain the quantification of this mute global phenomena. One of the most connoted attempts was done by the Kaufmann, Kraay and Matruzzi (KKM) index composite, who describes an average of six different indicator of a country's governance: voice and accountability, political stability, government effectiveness, regulatory quality, rule of law and control of corruption:

$$g_i = \beta_0 + \beta_1(\ln y)_i + \beta_2(a)_i + \beta_3(bd)_i + \beta_4(bd)x(a)_i + \beta_5(i)_i + e_i$$

While deploying the KKM, one of the most striking features upon the U.S. migration data is that immigration flows of individuals with no more than a primary education are quite small, both in absolute terms and relative to other educational groupings (about 500,000 individuals out of a total of 7 million immigrants). Foreign-born individuals with little or no education, however, may be undercounted by the census if they are in the country illegally or do not speak English. The largest group of immigrants into the United States (about 3.7 million) consists of individuals with secondary education from other North American countries (understood here to include Central American and Caribbean countries), primarily Mexico. Perhaps surprisingly, the second largest group (almost 1.5 million individuals) consists of highly educated migrants from Asia and the Pacific. Total immigration from South America and, especially, Africa is quite small (Burnside, 2004).

STEM Programs Best Practices and US Government Strategies

Different project and institutions have been created in order to boost the STEM programs coverage and performance, along the US context, where the United States Government has formulated a 2015 Budget Plan who pretends to anticipate the needs of the STEM programs, which includes:
A STEM Innovation Proposal: This proposal includes $170 million in new funding that will help to train the next generation of innovators.

- STEM Innovation Networks ($110 million): This program will award grants to school districts in partnership with colleges, and other regional partners to transform STEM teaching and learning by accelerating the adoption of practices at High School level that help to increase the number students who seek out and are well-prepared for postsecondary education and careers in STEM fields.
- STEM Teacher Pathways ($40 million): Targets the formation of 100,000 effective STEM teachers, while providing competitive awards to high-quality programs that recruit and train talented STEM educators for high-need schools.
- National STEM Master Teacher Corps ($20 million): This program will identify, refine and share models to help America's best and brightest math and science teachers to make the transition from excellent teachers to school and community leaders and advocates for STEM education.

It is worth mentioning that other entities such as the STEM Education Coalition, are design in order to assure the proper implementation of this strategies and projects around the US labor market landscape, who at the same time pursuit the achievement of a series of specific principles and goals based upon the accomplishment of the best practices originally defined for the STEM program implementation, such as:

• STEM education must be elevated as a national priority as reflected through education reforms, policies to drive innovation, and federal and state spending priorities.
• The US must expand the capacity and diversity of the STEM workforce pipeline to prepare more students for the best jobs of the future that will keep the U.S. innovative, secure and competitive.
• Among others.

US STEM Program 2018 Job Allocation Forecast

By taking into account the government strategies and STEM best practices previously defined, several forecast have been drawn in order to allocate the STEM project efforts into specific environments. Thereby it is of great importance to analyze the estimated results forecasted up to 2018, where for the year 2018, the government states that the STEM jobs are going to be allocated in accordance to their industrial and manufacturing demands and trends (please revise Table No 2).

And combined to the this state forecasts, it is of great importance to define the STEM fields over which the efforts are going to be focused on, please revise the Figure No 4, who clearly determines the specific areas of industrial and manufacturing acknowledgement supported (technically and financially by the US government).

Table No 2 STEM 2018 Labor Market 2018 State Trends

Projected STEM Jobs Need by State in 2018 and Ranking by Total Number of Jobs

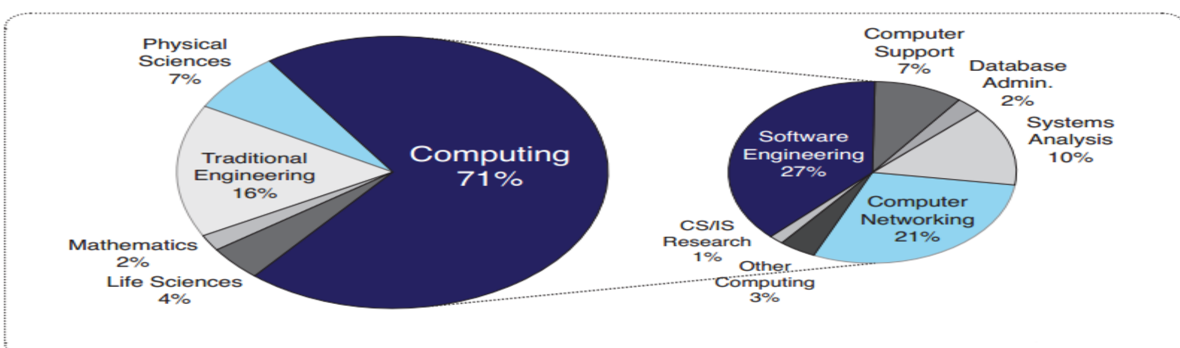
STATE RANK 2018	STATE	PROJECTED 2018 STEM JOBS
23	Alabama	110,000
47	Alaska	20,000
18	Arizona	166,000
36	Arkansas	52,000
1	California	1,148,000
14	Colorado	232,000
22	Connecticut	116,000
41	Delaware	31,000
27	District of Columbia	94,000
4	Florida	411,000
16	Georgia	211,000
42	Hawaii	29,000
40	Idaho	41,000
6	Illinois	348,000
21	Indiana	123,000
32	Iowa	72,000
30	Kansas	80,000
31	Kentucky	74,000
33	Louisiana	69,000
44	Maine	25,000
13	Maryland	241,000
9	Massachusetts	300,000
10	Michigan	274,000
17	Minnesota	188,000
38	Mississippi	46,000
20	Missouri	143,000

Projected STEM Jobs Need by State in 2018 and Ranking by Total Number of Jobs

STATE RANK 2018	STATE	PROJECTED 2018 STEM JOBS
44	Montana	25,000
37	Nebraska	48,000
34	Nevada	54,000
39	New Hampshire	43,000
12	New Jersey	269,000
35	New Mexico	53,000
3	New York	477,000
15	North Carolina	229,000
51	North Dakota	15,000
11	Ohio	274,000
29	Oklahoma	81,000
24	Oregon	109,000
7	Pennsylvania	314,000
43	Rhode Island	26,000
28	South Carolina	85,000
49	South Dakota	18,000
24	Tennessee	109,000
2	Texas	758,000
26	Utah	101,000
48	Vermont	19,000
5	Virginia	404,000
8	Washington	303,000
44	West Virginia	25,000
19	Wisconsin	155,000
50	Wyoming	16,000
TOTAL STEM JOBS		8,654,000

Source: Edie Fraser, 2012, "Where are the STEM Students?" My College Options & STEMconnector Report, 2012

Figure No 4 STEM Government STEM Areas of Support



Source: Data Source: US-BLS Employment Projections, 2008-2018 (http://www.bls.gov/emp/ep_table_102.pdf)

US Manufacturing Sector Competitiveness

Despite the previous statistics over the US STEM programs flaws and weaknesses, it is worth mentioning the US manufacturing sector is still a t its peak, were studies revealed by Deloitte on their 2013 report on the Global Manufacturing Competitiveness Index (GMCI), unveils that the US is directly competing with the Chinese (GMCI 10/10 point) and German Industry (GMCI 7.98/10) on the countries manufacturing competitiveness index rankings (GMCI 7.84 /10).

At the country level, it is of great value noticing that nations, such as Germany and the U.S., are the most competitive nations with respect to their ability to promote talent and innovation. On the other hand nations such as South Korea and Singapore are very competitive on multiple measures like researchers per million population and basic math and science test scores. But in order to obtain an overall look at the US manufacturing competitiveness one must review 3 core components: Technological prowess and size, Research support for national HEIs and Productivity (please revise Table No 3 above).

Conclusions:

After meticulously revising the associated literature, this analysis concludes the following:

The current US HEIs and US government measures to retain the foreign students enrolled on STEM program are not sufficient, since the US has the highest concentration (36%) of students interested in STEM programs and the country faces a large shortage of employees with STEM skills (alarmingly, 600,000 manufacturing jobs are going unfilled).

The US limitation towards the retention of the most talented Human talents is still one of the most obvious facts that encourage the Obama administration to stimulate the local industry performance through the design of complex STEM Projects (STEM Innovation Proposal: $170 million USD). Regardless of the current weaknesses and imperfections of the US STEM described on this theoretical analysis, the US still competes along the first 3 places on the global manufacturing ambience.

Finally… Despite the fact that this analysis only contemplates the first phase of a general investigation over the foreign STEM students impact on the US overall competitiveness (manufacturing sector) , one may infer that these STEM professionals truly adjust the countries competitiveness with their technological innovations, process knowhow and research competences.

Main Theoretical Framework

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Acknowledgment

The author´s gratefully acknowledges the Information facilitated by the STEM Education Coalition personnel, particularly James Brown and Aubrey DeVillez, appreciating any suggestions or notes regarding this work, at the following correspondence address: jargueta@iies-unah.org.