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Transforming Higher Education with Six Sigma

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Abstract.

Institutions of higher education (IHEs) are facing challenges on several fronts; low graduation rates, apprehension among students they may be ill prepared for real-life challenges upon graduation, rising questions of relevance of college education for public good, etc. In this paper, we show that six sigma is a transformative approach to tackle these challenges. Six sigma was pioneered at Motorola in late seventies and popularized at General Electric in the nineties. The second author subsequently articulated four natural laws showing that six sigma can improve the performance of all repetitive activities. Since much what we do from the time we wake up to the time we go to bed, including all that we do at work, is a series of repetitive activities, six sigma really is for life, meaning that we must all think, work, and live the six sigma way.

In this paper, we explain what six sigma is, how it is implemented, and what the benefits of implementation are. We show how six sigma may be used to improve the performance of all university operations, from student recruitment to graduation, including all the processes in between. We also explain how six sigma can to transform higher education. The ongoing six sigma training program at the Private Universities Council, Kuwait Ministry of Higher Education is summarized along with their plans to spread six sigma in their society. We suggest that six sigma is worthy for adoption by the International quality assessment agencies in higher education and ought to be pursued.

Introduction.

The INQAAHE conference and the acceptance of this paper for presentation could not have come about at a more opportune time. Institutions of higher education are struggling with high drop-off rates (In the United States the average graduation rate from public universities six years after first enrollment is under sixty percent; four of ten students entering four-year public colleges do not graduate even after six years!) Some have asked if the universities are being candid enough to tell aspiring student applicants how well they will be prepared for real-life challenges upon graduation. In the broader context, some have even wondered if college education is for the public good of the society reflective of challenges facing humanity. There is increasing evidence that institutions of higher education are not contributing effectively as leaders of intellectual processes. Rather, they are criticized of falling prey to market and political forces in exchange of sustainable funding. The explosion of the institutions of higher education with widespread private and cross-border providers has intensified this concern.

These of course are complex issues requiring decades of concerted effort by many segments of societies. However, we propose that six sigma is a suitable framework with which substantial progress may be made and ought to be pursued. Developed at Motorola in the early eighties, six sigma is the methodology to use to operate all repetitive work processes in the best possible manner. When this is done, defect rates tumble, customer satisfaction skyrockets, and all the benefits of six sigma accrue. In this paper we show that six sigma is not just right for improving the performance of university operations, from student recruitment to graduation, but also for transforming higher education itself.

The organization of this paper is as follows. We begin with an operational definition of six sigma. Then, a synopsis of how six sigma implementation is presented. Next, we discuss how six sigma may be applied to improving the performance of all university processes followed by an outline of how six sigma may be used to transform higher education. Next, we present the six sigma training program currently underway at the Private Universities Council, Kuwait Ministry of Higher Education, and outline how PUC plans to spread six sigma in the Kuwaiti society. We conclude the paper with some thoughts on how societies could use six sigma not just in higher education but also in all the other sectors, Government and private, to increase GDP, alleviate poverty, and to achieve globally competitive positions.

Six Sigma Defined.

The Greek symbol σ (sigma) is a statistical term denoting "standard deviation". Standard deviation denotes how far away the data points are from the mean, typically, and it may be computed with a formula. The phrase six sigma refers to several things: One, six sigma is a performance level - for a six sigma process, 6 standard deviations each may be fitted between the mean and the upper and lower specification limits. Allowing for machine wear & tear and operator fatigue, this performance level equates to 3.45 dpmo (defects per million opportunities) for a process with a single-sided specification (or 6.9 dpmo for a process with a double-sided specification). Six sigma also is a disciplined and data-driven approach to insuring that repetitive work processes function in the best possible manner. The primary goal of six sigma is to minimize defect levels in the outcomes of work processes, a defect being anything that causes customer dissatisfaction. Maximizing customer satisfaction leads to improved bottom-line performance and globally competitive positions.

Six Sigma Enlightenment.

We begin with an assertion six sigma may be used to improve the performance of all repetitive work processes. This assertion necessitates that the definition of "work process" must be clearly understood. Simply put, a work process is any activity that consists of a series of steps. Viewed this way, you would concur, nearly all human activities are repetitive work processes. Now, every work process has an outcome by which its performance is measured. In six sigma jargon, the outcome of a work process is variously called effect, output, or response variable. Response variables (outcomes of work processes) have specifications imposed on them by the customers they serve. Out-of-spec response variables therefore lead to defects as perceived by internal or external customers. Minimizing defect levels, the goal of six sigma, is synonymous with achieving the highest levels of customer satisfaction. Maximizing customer satisfaction leads to higher market share, improved bottom-line performance, and globally competitive positions. Realization of these objectives is made possible by four fundamental laws of nature that are the foundation of six sigma.

1. The Law of Cause and Effect (India, ~1500 BC): The first natural law states: "All that we do have causes and effects. Furthermore, the effect of one cause is in turn a cause for another effect. The endless chain of cause and effect is called *Karma.*" For six sigma work, this natural law has been adapted to say: "*For every effect, there must necessarily be a cause (or causes).*" The effect represents the outcome of a work process by which its performance is measured and whose performance is sought to be improved. Although the law of *Karma* does not identify what the causes are, it should nonetheless be a source of great comfort for anyone aspiring to improve the performance of work-processes knowing that there are *causes* influencing the outcome. If these causes could be found, and they are found with six sigma, we would work on them to improve the outcome.

Fundamentally, there are three types of causes and their description necessitates access to two other laws of nature.

2. The Law of Natural Variability (Germany, 19th Century AD): The second natural law, adapted from the work of the German scientist Frederick Gauss stipulates the first type of causes. It states, "*All processes and transactions exhibit a certain amount of inherent variability no matter how well they are designed*." In other words, perfection (zero defects ad infinitum) is not in the plan of nature. However, adherence to six sigma principles will ensure that defect levels are as small as they can theoretically be. This natural variability (also called common cause variability in six sigma jargon) occurs due to a variety of unknown and/or uncontrollable causes and it often follows the familiar bell-shaped curve (normal probability distribution).

3. The Law of Special Causes (USA and Japan, 20th Century AD): The third fundamental law adapted from the work of a number of American and Japanese quality control professionals (Shewhart, Deming, Juran, and Taguchi, among others) specifies the second and third type of causes. This law states, "*The inherent variability in the outcomes of work processes is worsened by causes that are discoverable. These causes are called assignable (or special) causes. Tracing and then eliminating these causes (causes of the second type), or*

setting them at proper values (causes of the third type) as appropriate means the process or transaction is returned to its natural state."

4. **The Law of Variability due to Measurement Error**. Measurement errors increase the variability in the outcomes of work processes and therefore defects. To achieve the desired improvement, measurement errors must constitute a small fraction of the variability in the response variables due to all assignable causes.

Figure 1 graphically illustrates these ideas. The vertical line labeled Target is where the outcome should be. Figure 1(a) shows that not all data points can lie on target; there will be a certain amount of inherent variability as depicted in Figure 1(b) in every process or transaction outcome consistent with common causes as per the second natural law. This inherent variability is worsened by measurement error and by discoverable causes (for example, the distribution may become skewed, the mean may veer off target, the standard deviation may increase as per the second natural law (see Figures 1(c) and (d)). The goal of six sigma is to return the process or transaction outcome to its natural state.

These natural laws emphasize that the response variables of work processes can only be returned to their natural state with the associated inherent variability due to uncontrollable causes and nothing more. If defect levels in terms of customer satisfaction issues were still too high with the process in its natural state, then we would have to return to the drawing board and examine all the potential problems outside the scope of the existing process under scrutiny to achieve further improvement. Some illustrative examples of such problems are supplier issues, raw material quality, design issues, improper business models, inadequate equipment, technologies, etc.

These laws certainly suggest if the entire variability in the response variables is from common causes, then, no improvement from six sigma is possible. However, suggesting that six sigma will not improve the performance of their process at the outset implies that the entire variability in the selected outcomes is due to common causes. We will come to know how much of the total variability was due to common causes only in hindsight, after six sigma has been implemented, not before! These ideas are clarified in Figure 2.

Six Sigma Implementation

Since six sigma is all about enhancing customer satisfaction, it should make sense that we would begin with an exercise to identify who the customers are. Some times the answer is obvious and at other times, it is not. Having identified who the customers are, the next step is to find out what is important to the customer, called customer critical-to-quality (CTQ), in six sigma jargon. This is a critical step to success with six sigma because the supplier perspectives on what is important to customers can often vary substantially from customers' own perspectives. Furthermore, the CTQs as the customer expresses them are some times fuzzy, not amenable to six sigma implementation. In such a case, the fuzzy CTQs must be translated into actionable items suitable for six sigma implementation. A statistical tool to carry out this translation is Quality Function Deployment (QFD). The results of the QFD exercise is a set of prioritized CTQs and a list of strongly correlated outcomes which when improved with six sigma will enhance the CTQs. The approach therefore is to implement six sigma on the outcomes of work processes identified in in QFD one at a time.

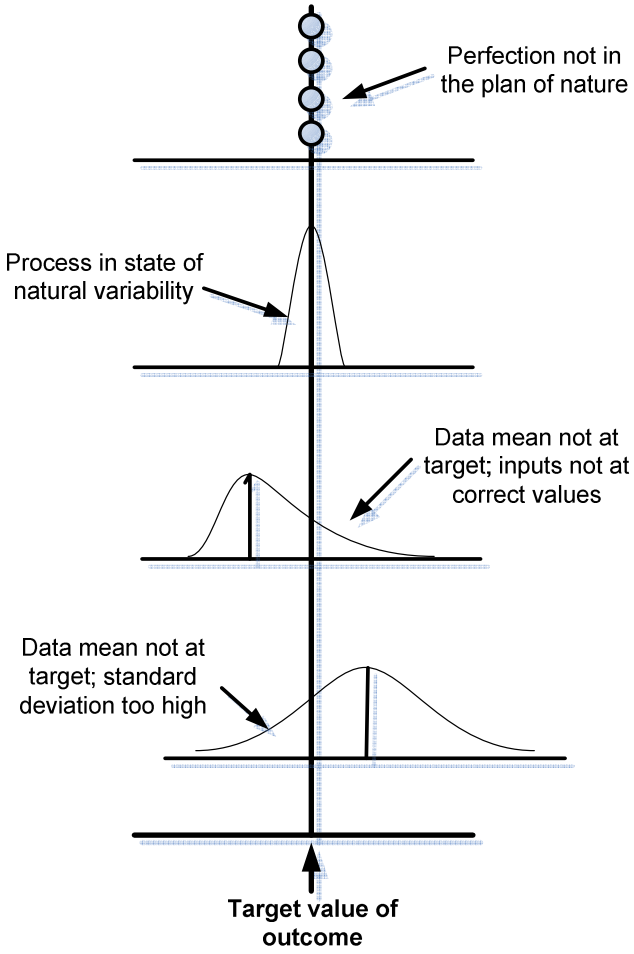

Figure 1. Returning the Process to the State of Natural Variability with Six Sigma

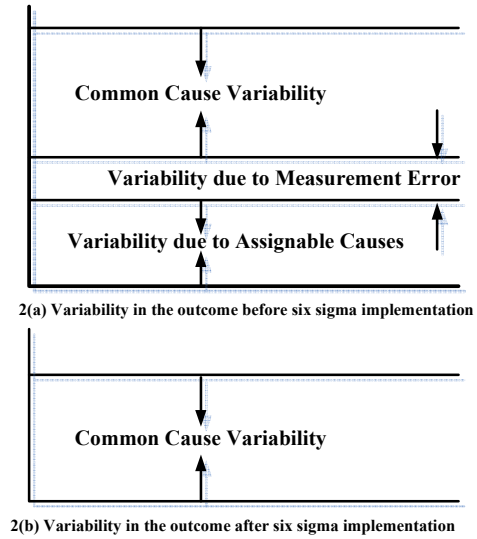

Figure 2. Various Components of Variability before and after Six Sigma Implementation

With a specific work process selected for six sigma implementation, is it is now the appropriate time to prepare the Project Charter. The project charter is a short document, a page or less, that outlines what problem or problems the customers are having giving rise to dissatisfaction. It lists the outcomes requiring improvement, states project goal, identifies the project sponsor and the six sigma team who will work on the project, and provides the start and end dates for completion.

With this background work completed, and armed with the four natural laws, we may now write down a step-by-step procedure for implementing six sigma.

Phase One: Scope

Step1 is to **Formulate the Problem Statement** articulating what is giving rise to customer dissatisfaction (e.g., 35% of train arrivals are more than 10 minutes late).

Step 2, In Step 2 we define the outcome of this work process (e.g., **Arrival Time, Minutes from Target)**.

Step 3, In Step 3 we state the project goal (e.g., **Reduce Late Arrivals, let us say, by 50%**). The desired improvement is speculative at this point since we do not know the extent of natural variability present in the process. Nonetheless, the benefits of defect reduction will be likely be substantial. An estimate of the financial benefits if the targeted benefits are realized should be included.

Phase Two: Measure

Step 4 In Step 4 we **Draw a Process Map** showing all the steps in the process including the linkages between steps. The process map in the case of the Train Travel Process will include all the steps from the time the train leaves the origination station till it arrives at the destination station.

The *Karma* concept states the outcome of this process, Arrival Time, is impacted by causes. It does not tell us what the causes are. We wish to determine what the causes are with six sigma so we may work on them to improve the outcome performance. Customer dissatisfaction has emerged as an issue because there is excessive variability in this outcome, that is, the average is not where it should be or could be and the standard deviation is too large. Some of the observed variability in the outcome will be due to common causes which we cannot do anything about within the scope of the problem being scrutinized, but a lot of the variability may be due to causes that we can do something about (assignable causes). Every one of the steps on the Process Map is a potential special cause, i.e., a possible contributor to the variability in the outcome and therefore defects. In a future step, we shall determine which of these potential causes are in fact responsible for introducing variability in the outcome.

Step 5 is to **Validate Measurement Systems**. The central idea here is that the variability in the outcome must come from causes (any one or more of the steps on the process map) and not from errors in the measurement systems. Take as an example, a Voting Process involving voters coming into a polling booth for voting in an election. Here, voters fill out ballot papers, which are processed by a vote-counting machine, and the interpreted results are generated. Clearly, we would want the variability in the outcome (Interpreted Results) to come from causes (Voter Intent) and not from errors in measurement systems (confusing ballot paper

design, error-prone vote counting machines). In fact, such errors must be a very small fraction of the margin of victory between the top two candidates or else the election results would be suspect. It is extremely important to validate measurement systems before proceeding to the next step in the six sigma implementation strategy.

Step 6 is to **Collect Data on the Outcome(s)** [response variable(s)] for the purpose of determining the starting defect levels.

Step 7 is to scrutinize the data collected and **Establish the Current Defect Levels**. It is important to establish the baseline (current performance) so improvement from six sigma can be properly catalogued.

Phase Three: Analyze

Step 8 In Step 8 **Properly Designed Procedures** are employed to collect data on the potential causes and the response variable(s). As previously stated, every one of the steps on the process map is a potential cause.

Step 9 involves analyzing the data collected for **Identifying the Causes** (called major impact factors or vital few causes) that are responsible for introducing variability in the outcome.

Phase Four: Improve

Step 10 In Step 10 the **Major Impact Factors** so determined **are either set at the optimal values or are eliminated** as appropriate. When this is done, the average of the response variable moves in a favorable direction and the standard deviation decreases and all the benefits of six sigma accrue.

Phase Five: Control

Step 11 The last step is to put in place a plan to **Monitor Response Variable(s)** so benefits of six sigma are sustained and the problems once fixed, stay fixed.

We suggest a two-phase procedure for transforming of higher education with six sigma In the first phase, six sigma would be implemented on all the existing processes and transactions on college campuses to insure that they are functioning in the best possible manner. The second phase will focus on the transformation of higher education with six sigma.

Improving Existing Processes with Six Sigma. College education necessarily involves a large number of repetitive work processes. Processes generic to educational institutions include: (1) Recruitment, (2) Admission, (3) Registration, (4) Academic advising, (5) Semester-long study process that gets repeated until the end of the academic program, and (6) Graduation. In addition, there are numerous support processes on university campuses. They include libraries, information technology services, lodging, catering, and transportation, parking, and financial aid, and many others. The efficacy of the educational experience depends not only on the resources at hand (faculty, laboratories, physical facilities, etc.) but also on how well these myriad of repetitive work processes are operated.

In order to provide a simple illustration for the methodology, we select three outcomes for the IHE work processes which contribute to performance: (1) fraction of incoming students who graduate, (2) graduation time in years, and (3) cost of obtaining the baccalaureate degree. For illustrative purposes, let's us say that data for the past fifteen years suggests the average six-year graduation rate is 60% with the standard deviation of 10%. To achieve improvement, the average would have to be moved in a favorable direction (in this case, increased) and the standard deviation reduced. Now, as per the first natural law, the outcome (graduation rate) is definitely impacted by causes. This law provides a certain comfort level knowing that the outcome is impacted by causes. If these causes could be found, and

they are found with six sigma, performance could be improved. However, as per the second natural, some of the defects will be due to causes that are uncontrollable within the scope of the project under scrutiny. In other words, 100% graduation rate on average is not possible. That said, as per the third natural law, some of the sources of defects will be due to the causes that are discoverable. Six- sigma will uncover these causes and when they are eliminated or set at the correct values as appropriate, the average graduation rate will increase, the standard deviation will go down, and the benefits of six-sigma will accrue.

When six- sigma is fully deployed on the recruitment-to-graduation process chain as well as on the support processes in universities, it will be possible to claim that the university operations are being operated in the best possible manner. Further improvements will be possible only with design changes and through improvements in the upstream process (in this case, high school processes). It is theoretically possible to continue with improvement by tackling the high school processes and all upstream processes with six sigma until constraints imposed by nature (for example, parents) are encountered; no further improvement is possible once these constraints are reached. The second author discusses this issue in his monograph, "*A Small Step for Man: Zero to Infinity with Six Sigma*".

This discussion emphasizes that the extent of natural variability present due to uncontrollable causes in any process becomes known only after six sigma has been deployed. Thus, if a University opines that the performance of its higher education work processes cannot be improved, it is implying that the entire variability (defects) is due to uncontrollable causes. This of course is an untenable assertion. Improvement with six sigma will likely result in every case; the extent of improvement from one institution to the next and from one nation to another however will vary because the extent of natural variability in all these cases is different.

Transforming Higher Education with Six Sigma. Six sigma offers institutions of higher education a powerful mechanism with which to examine the efficacy of their offerings and to improve them. Once six sigma has been successfully deployed on all existing work processes on a university campus, the next task is to determine how well the outcomes of these existing work processes align with the justifiable needs and requirements of the society. If they do not, serious thought must be given to revising the work processes so that they do.

To assist with identifying the need for revision, a prioritized list of the society's expectations of college graduates has to be developed. This exercise too can be undertaken with the Quality Function Deployment technique described earlier, requiring stratified sampling of the heterogeneous population. Once the societal CTQs are determined, the outcomes therein must be aligned with the outcomes of existing work processes giving a path forward what processes would have to be revised. Having mastered six sigma concepts with existing work processes will make it possible to put together these "new" work processes so that once implemented will give rise to few defects.

The authors concur that transforming higher education will be a significant effort spanning a decade or more requiring the involvement and support of many segments of societies. We strongly feel though that the task is time and the reward to successful pursuit will be will be well worth the effort and the efforts ought to be pursued.

Six Sigma Regulatory Model at the Private Universities Council (PUC).

PUC is a semi governmental establishment formally founded by the Council of Ministers (decree # 359/2001). It comprises nine specialists possessing a wide range of experience and commitment to the field of higher education. The Minister of Higher Education chairs the

Private Universities Council and its members are all appointed by the Council of Ministers. The PUC was established to fulfill the following tasks:

1. To decide on the licensure of a private higher education institutions
2. To determine the accreditation requirements of private higher education institution, and follow-up quality assurance measures
3. To adopt universal standards for licensure and accreditation
4. To establish measures of accreditation and validation of academic degrees issued by the private institutions.
5. To oversee the sustainability of private institutions and provides advice.

It was recognized early on that the functions of the PUC were suitable for the adoption of the six sigma philosophy. The license procedure requires the educational institution to visualize the mission and goals for the educational process. The combined goals of universities require them to attain quality in higher education delivery. The bylaws consist of specific measurements for key indicators that are critical to quality. The measurements are obtained after every academic semester and sent to the PUC. PUC through the accreditation committee analyzes the key academic indicators as set by the accreditation criteria and other QA schemes. The accreditation committee discusses the required improvements, and provides guidance. The improvement recommendations are communicated to the General Secretariat, which sets up control actions, and conveys them to the colleges. The colleges implement the control actions and the process is repeated. This superficial view is a compact illustration of the basic steps of the six sigma methodology: **Scope, Measure, Analyze, Improve, and control.** The process is illustrated in **Figure 3.**

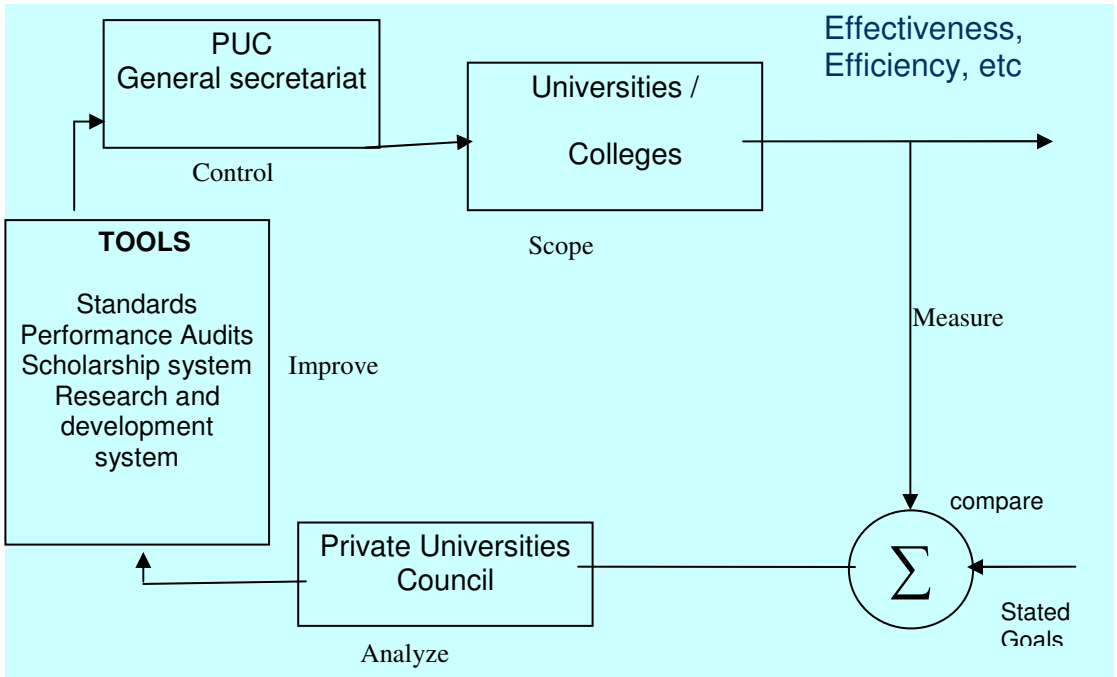

Figure 3: PUC QA Regulatory Model as Related to Six Sigma Methodology

A critical feature for the PUC system is its ability to mobilize, network and utilize available expertise through careful selection, training, qualification and certification of professionals; such as the 'technical committee of engineers', evaluation teams for institutional accreditation, external experts, and international accreditation agencies. PUC also certifies local qualified professionals as Certified Educational Institution Auditor (CEIA).

Quality Assurance Management Criteria and Procedures. The higher education institution must be internationally affiliated with one of the highly recognized and accredited foreign higher education institutions. The top 200 listing of The Times Higher Education-QS is taken as the benchmark for selecting the affiliate institutions. Based on the accreditation criterion, the private higher education institutions are locally approved for accreditation by an independent external team formed and trained by PUC. Program quality management, on the other hand, is obtained through internationally recognized accreditation agency in the program field of specialization.

Between 2002 and 2004, the PUC developed an innovative process to manage the quality of private higher education in Kuwait. As outlined briefly here, the PUC sets up institutional accreditation criteria. At the onset of these criteria, the PUC lawfully entrusts the council of trustees in each establishment, as the highest authority, to manage its credibility and protect its interests (see Annex 1).

Each operating higher education institution is mandated to be affiliated with highly recognized international partner. Similarly, every academic program is mandated to have international accreditation. The management of the quality of private higher education is dependent on this range of PUC procedures and protocols. Since its establishment in 2001, the PUC has approved 5 out of 34 requests to establish private higher education institutions; two colleges and three universities; additional 7 licenses were granted by 2008. Many of the private higher education institutions assume the American system of education, two adopt the Australian and two follow the European system (see Table I). Over 12,500 students are enrolled in 8 out of the 12 licensed institutions, studying in higher education programs of various levels; diplomas, Bachelors, and Masters. The fields of study are given in Table 2.

Table I. International Partnership

Education System/Country	**Number of Affiliated/Branch Institution (Licensed & to be licensed)**
U S A	7
U K & European	4
Australia	2
Canada	2
India	1

Table 2 Fields of study

Diploma	Bachelor	Master
Maritime	Education	General &strategic management-MBA
Engineering	English language	General MBA
Management and business administration	Communication, Journalism & media studies	Law
Information science & technology	social sciences	Physical Education
Engineering & design technology	Hospitality and tourism	
Nursing	Arts	
Health science	Engineering Technology	
Para legal	Management and business administration	
	Computer science	
	Law	
	Medical and Health science	
	Engineering	
	Information science & technology	

Outcome of Accreditation. There are many important outcomes of the Kuwait system for ensuring quality in private higher education. All the higher education institutions have obtained positive quality assurance from their international partners, and hence they are awarded the institutional accreditation by PUC. Three academic programs were suspended. Two warnings were issued for programs operating without a license. One postgraduate program achieved international accreditation (MBA at Kuwait Maastricht School). Three private higher education institutions awarded their graduates local and international degrees: ACK from TAFE institutes, Arab Open University from Open University UK and Kuwait Maastricht Business School from its mother Maastricht Business School.
The tangible benefit of six sigma framework of external quality assurance was realized via the reduction in the defects levels as measured by the various indicators in the regulatory process. These benefits were measured in the unit time of one semester. Longer term improvements were noticed during the institutional accreditation process for all participating institutions. In the first round of accreditation concluded in 2006 there were three IHE's which were accredited for two years, and two accredited for three years. In the second round of accreditation which was done in 2008 there were three IHE's which accredited for three years, two are expected to receive longer terms. This illustrates the overall effectiveness of this model for continued improvement which underpins the six sigma philosophy.

The Six Sigma Leadership Program. The Private Universities Council (PUC) and the private HEIs in Kuwait have embarked on a six sigma project to realize its benefits on selected work processes. Under the auspices of this project, the leadership and staff of PUC and several faculty members/administrators from each of the five participating colleges and

universities are undergoing six sigma training. PUC is charged with the assessment and quality assurance of all private universities and colleges in Kuwait. Its goals in this project are first to organize and operate its internal processes the six sigma way and second to insure that colleges and universities are following six sigma principles in their repetitive activities. There are twenty one participants in all representing these institutions. Each institution has selected a six sigma project involving one of their work processes to work on during training. Thus by the end of year-long training, the projects would be successfully completed. Once the six sigma concepts have been mastered, the intent is to replicate six- sigma on all major work processes under the purview of their respective institutions.

The project is operated as knowledge discovery, organization, sharing and processing process. Much information on work processes are scattered within HEIs and within PUC itself. Selecting and working targeted project involved research and at the same time its application towards improvement.

This project is also an excellent opportunity to introduce six sigma in Kuwaiti society at large. To begin, a course in six sigma would be introduced in the curricula at the senior/MBA level. Public and private sector organizations could provide projects for the students to work on. The arrangement is a win-win for all those involved. Organizations will benefit from the successful completion of projects and access to real-life projects is hugely beneficial to students. The project has gone through two training sessions were 6 projects were identified and presented. The teams selected practical problems from their organizations with specific targets to enhance performance and reduce defects levels. The final outcome and evaluation of the projects will be presented in May.

The participating colleges have expressed interest in further utilization of the methodology through internal course offerings and community services. The local public and private sectors in Kuwait are perfect candidates to receive six sigma training and utilize its benefit to achieve business excellence. This in turn would enhance the possibility to engage the leading government agencies in the exercise, especially as the Kuwait Petrochemicals Sector have seen early benefits in the past few years, following an executive presentation made by one of the coauthors in 2004.

Profound Implications of Six Sigma for Societies.

Armed with the fundamental understanding of six sigma and its usefulness for higher education, it is now possible to present a bigger picture, that is, why the pursuit of six sigma is essential for the wellbeing of all societies.

Decades of travel to various countries around the world, some developed, some emerging, and some still in the depth of decline, has led the second author to conclude that the number of defects in all products and services of nations distinguish developed nations from emerging ones. These ideas are clarified in Figure 4. Suffice it to say, we do not have the quantitative data to back up this plot but we do believe it is accurate in a qualitative sense. Whether the numerical values of defect levels shown for a given nation or its relative location vis-à-vis other nations, is correct or not is immaterial. What is important to note is that emerging nations are characterized by high defect levels while developed nations are characterized by low defect levels. Now that you have understood, six sigma is *the* approach to reducing defect

levels in all work processes, it should be clear emerging nations really have no choice but to embrace six sigma in large measure if their vision of joining the ranks of developed nations is to become a reality. In the same vein, developed nations too have no choice but to embrace six sigma if their globally competitive positions are to be maintained so their standard of living is not compromised. Which nations are apt to embrace six sigma as a national movement too is a fascinating subject. For the perspective of the second author on this topic, the reader is referred to his recent monograph, "A Small Step for Man: Zero to Infinity with Six Sigma".

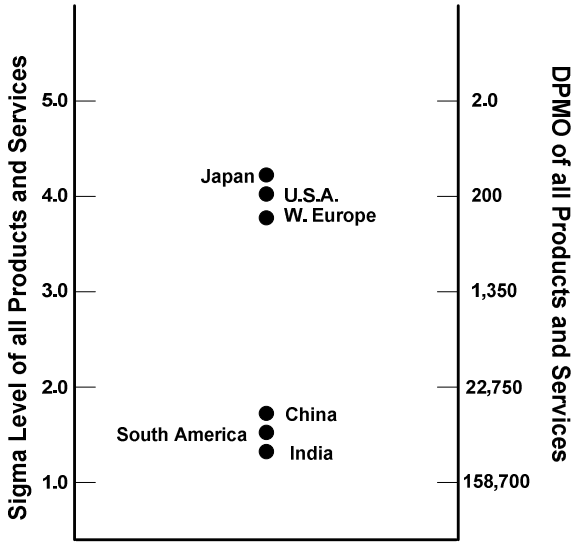

Figure 4 Defect Levels of Developed and Emerging Nations

To Conclude.

Fundamental perspectives on the role of six sigma for transforming higher education have been presented. Based on first principles, we have outlined how six sigma may be used to operate all the existing work processes on university campuses in the best possible manner. Furthermore, we have illustrated the validity of the six sigma methodology for overall governance of the higher education system via integration of the university operations with the quality assurance agency feedback. With this accomplished, it is suggested that six sigma be considered for transforming higher education so that the all the IHE work processes are better aligned with the society's justifiable expectations. We have shown why it is important for all societies to embrace six sigma and in this context, it should be clear that IHEs would have to play a leading role since the responsibility of who will be called upon to accomplish these tasks will rest on the institutions of higher education.

Acknowledgements.

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ANNEX 1. PUC Performance Indicators

1.1.Performance Indicators: Effectiveness

- Grade distribution/dispersion
- Distinguished students per total
- Class distribution per faculty
- Intellectual output per marketed
- Scientific quotations
- Resource distribution

1.2Performance Indicators: Productivity

- Measures output per academic staff
- Research output
- Graduates
- Intellectual outcome
- Training outcome
- Net profit

1.3Performance Indicators: Efficiency

- Measure resource utilization capacity
- Student output per input
- Frequency of change of specialization per students
- Students per academic staff
- Students under probation

1.4Performance Indicators: Internal Structure

- Faculty members per assistant and/or technician
- Faculty members per admin staff
- Faculty rank per total faculty
- Course/section offering
- Class/lab area per students

1.5Performance Indicators: Growth and Renewal

- New faculty members per total
- Ratio of foreign students to total
- Business incubators graduated
- Part time staff to total