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SIX SIGMA - DMAIC Framework for Enhancing Quality in Engineering Educational Institutions

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ABSTRACT: *Six Sigma is a proven business strategy for improving the organisation's effectiveness and achieving higher levels of performance. Six Sigma applications have proved its success in product and process / service Industries by deploying any one of its models like DMAIC or DFSS during implementation. In the recent times, Educational Institutions are attempting to leverage the success of Industries in improving their efficiency and the quality of service that are delivered by them. In the context of Educational Institutions, the customer and products are complex phenomenon to describe unlike an Industry. Engineering Educational Institutions, under the globalised Industrial scenario faces lots of challenges in their service offerings of Quality education and also in their output of Students as products for employment in Industry. This issue of quality in higher education is a concern not only for the stake holders, but also for the society at large. There have been many initiatives at the National level by government and other interested stake holders at the macro level. Attempts have been made in this work to deliver a broader framework of DMAIC approach to impact quality of engineering education at the micro level of Institution themselves by leveraging the success of Industries in applying six sigma for complex problems.The scope of the work also includes review the published literatures related to this work*

KEYWORDS: *Six Sigma, DMAIC, Engineering Education, Educational Enterprise, Engineering Colleges*

I. INTRODUCTION

SixSigma and its Success with Industries

Quality is a measure for success of any organisation. It helps in setting metric for achieving higher goals of accomplishments from the historical data of the own organisation and for bench marking the current level of performance with leaders in the particular domain towards setting targets for achievements. It also helps in continuous improvement and excel in the given function. There have been many initiatives of Quality in the Industries for achieving higher standards like Zero Defects, TQM, 5S and many others. Quality Gurus like Deming, Juran and many others during various phases have immensely contributed to the Quality movement that benefitted the Industries at large. One such Quality movement is Six Sigma, which originated at Motorola in early 1980s [1] and was recognised with the prestigious Malcom Baldrige National Quality Award (MBNQA) in 1988 [2]. Six sigma was popularised by demonstrating it as a successful business model, by Jack Welch at GE during late 1980s and 1990s [3]. Success of Six Sigma either in Motorola, GE or any other organisations later can be attributed to the Management and Leadership commitments. Six Sigma world is not always a smooth one and requires the patience of a saint, never-give-up philosophy and long-term perspective to work on Quality [4]. Some of the organisations failed in its first attempts of implementation in making considerable business impact, recognised that they did not create enough of sustainable infrastructure or force fit Six Sigma into the organisation and without Management Support [4].

Six Sigma is a structured approach and a discipline. DMAIC (Define, Measure, Analyse, Improve and Control) is the most familiar model of Six Sigma to the Industries in general, which is applicable to both process and product Industries. This model leverages effective utilisation of existing resources, without any additional investments on resources or infrastructure to achieve entitlement [3] in Six Sigma implementation in delivering business results. Basically DMAIC strategy aims at *low-hanging* fruits. Design for Six Sigma (DFSS) is another model aimed at delivering defect free products / process with a focus at the design stage itself. It is largely applicable for completely new process or product development, or new design to process or product quality when existing process / product quality attained *entitlement*

Six Sigma methodologies in brief, starts with the customer by closely understanding their needs / expectations, making appropriate changes / improvements to the process / product and delivering the solution that exceeds customer expectations rather than meeting the expectations.

II. QUALITY CHALLENGES OF THE ENGINEERING EDUCATIONAL ENTERPRISE:

Quality and its sustenance in higher educational Institutions, more particularly in professional Institutions is a great challenge for the mere existence of the educational Institutions themselves. Employability of the students produced by the Engineering Institutions, for employment by the Industry at 25% [5, 6] is a major cause of worry for all the stake holders and has been elaborated in [7]. Apart from the need for absorption by the Industries for employment, the products of Engineering Institutions have also to be equipped with the knowledge necessary for carrying forward research work in institutions of higher learning. The requirements of the customers (Industry & Research Institutions) of engineering Institutions from its products (students) are quite different, Industry requiring more emphasis on practical knowledge for applications and applied research, while research institution requiring strong knowledge on concepts for theoretical research. This throws a good challenge for the Institutions and its products. Unlike the Industry, the engineering Institutions have to meet the needs of complex demands of varying stake holders, regulatory bodies like AICTE, funding members for the educational process like parents, Industries under globalised scenario and expectations of students themselves as stake holders in the input process.

Educational Institutions in general and Engineering Educational Enterprise (EEE) in particular, have been attempting to address the Quality Challenges of EEE by leveraging various models that were found to be successful in Industries for this complex issue. In this work, attempts have been made to focus on Six Sigma methodology towards this cause, review the literatures towards this work and deliver a broader frame work to be carried forward at the Institutional level

III. LITERATURE SURVEY:

Joan [8] in his work has briefed on how to apply Six Sigma methodology to project levels in the Mechanical engineering department of the Institution, which is comparable to Green Belt Projects of a Six Sigma Enterprise and is not dealt on the frame work at the Institution level, nevertheless explains the usefulness of six sigma to educational Institution. Prabhakar and Dinesh [9] in their work explained how Six Sigma Methodology to a specific problem of increasing the pass percentage of students in Engineering Institutions similar to that of a task as explained by Joan [8]. Jayanta and Robert [10] in their work very nicely brought out the usefulness of Six Sigma approach in impacting quality and productivity improvement in higher educational Institutions in United States. Interestingly, authors have brought out the wastages / underutilisation of resources by quantifying academic work of 9 months in a year, with an idle time of 3 months on resources. They briefed further on, whether academic institutions can be run like a business enterprise, quantifying the importance of faculty role and explained the lack of investments in their development. They have also briefly explained all the 5 phases of DMAIC model. Ramasubramanian [11] has nicely captured in his literature the various roles of Six Sigma, DMAIC one of the most familiar model of Six Sigma and broadly listed various tools applicable in various phases of Six Sigma to educational institutions at macro level. The focus is not to dwell into the application of six sigma to the specific issue under discussions Imam et. al [8] briefed in their work traces the Six Sigma origin, development and the different phases of the Six Sigma Methodology. They also compared various categories of educational system across the globe. Interestingly this article quantifies levels of defects generated across global poles in products and process. It is not within the scope of the work to include suggesting a method or approach

Ramanan et. al [7] in their work attempted to explain the application of Six sigma in addressing employability issues of Engineering graduates, which is task specific similar to that of [8] & [9]. Sean [13] while attempting to explain the implications of Six Sigma in Industry and educational Institutions narrated the various roles, tools and phases of the Six Sigma model and has not delivered a frame work Ramanan et.al [14] focussed in explaining the necessity and benefits of having Six Sigma as a measurement metric for measuring quality of higher education.

IV. SIX SIGMA – DMAIC FRAME WORK FOR ENGINEERING EDUCATIONAL ENTERPRISE (EEE)

From the success and also from the failures of the Industry from Six Sigma implementation, it is confidently learnt that effectiveness and benefits from Six Sigma Implementation is largely dependent on Leadership / Management commitments and involvement of everyone in the process, of Six Sigma deployment.

Hence, the delivery of a successful frame work for EEE, starts from thetopmost level of the enterprise, thus ensuring commitment and support for six sigma deployment leading to measurable results.

4.1System and Sub-System of DMAIC and its Analogy to EEE

DMAIC as briefed in [7] is the process improvement methodology of Six Sigma approach either at the system level or at the component / task level for the product or process Industry. It shall be of benefit in explaining the model and frame work with an example of a product and apply the analogy to EEE for system level approach.Fig.1 captures one of the highly sophisticated, highly safety critical medical device from GE [15] used ininterventional diagnostics and also in procedure like stenting in coronary artery of the heart. The medical device as a system [Fig. 1], integrates various sub-systems [Fig. 2] by leveraging cutting edge technology across various domains of engineering [15] in delivering the flaw less function to the Doctors and patients. We can extend the same analogy of the System approach to EEE, which has to integrate with various sub-systems of like various Departments of Academic Excellences, various departments of Administrative functions and various external agencies like regulatory authorities, investors (parents), society etc. in delivering a flawless service and outputs from EEE. Fig. 3 covers a broader System and Sub-System involvement to an EEE and can be extended / expanded / modified according to the structure and discipline of EEE.

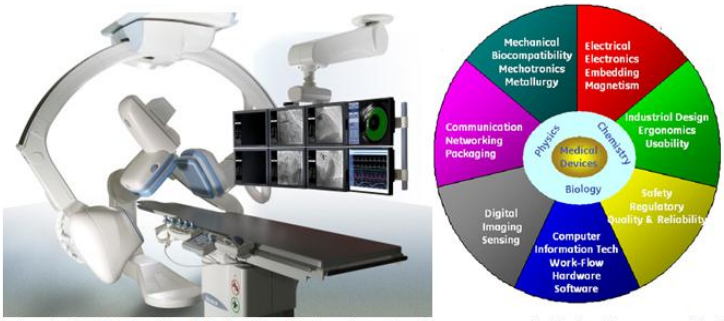


Fig.1 & 2 Typical Medical Device & System and Sub-System [15]

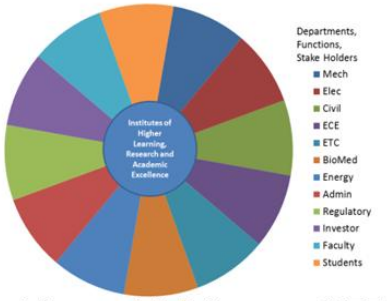


Fig. 3 System & Sub-Systems of EEE

4.1.1Impact of Quality – Flowing from Component to Sub-System to System

It could be appreciated from the Industrial product example explained here, if the system has to function flawless, each one of the components as small as a screw or a capacitor etc., in the sub-system has to function flawless all the time. Hence it can be realised that the importance the smallest component like a bolt in a complex product is as important as the system itself in its flaw less function. This analogy is applicable to educational Institutions comprising of various functions, departments, internal and external shareholders etc. For example, a typographical mistake in a mark sheet of an EEE by a clerk in an examination section of an administrative department is as important as a Researcher's publication in an accredited journal in measuring the Quality of an Engineering Educational Enterprise.

4.2 Typical DMAIC Model for EEE and aligning it with Quality System's Vision and Mission

It could visualise EEE as a system comparable to that of the product as explained earlier. Each of the EEE has its 'Mission and Vision' (V&M) statements towards what they want to achieve, by aligning Six Sigma model with Quality System's vision and mission it can be easily tracked towards measurable objectives at all levels. A generic DMAIC model of an EEE is depicted in Fig. 4 with broader objectives to be achieved in each one of the Phase of the DMAIC Six Sigma Model towards EEE. This frame work can be adopted at sub-system and also at the individual levels by having the V&M or 'Goals and Objectives' (G&O) by aligning it with a flow down from system level to component. To achieve these objectives Industries have adopted a structure of Six Sigma Roles towards effectiveness and efficiency of deployment and sustenance.

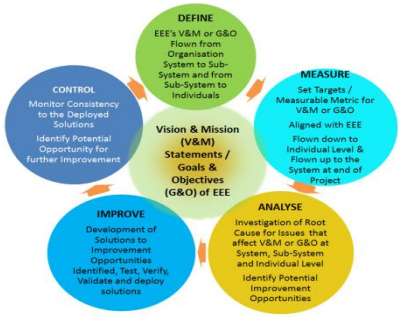
4.3 Typical DMAIC Structural Model for EEE

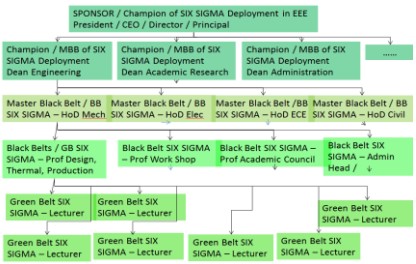
As explained earlier, success of Six Sigma depends on leadership involvement and commitment. The head of the Organisation – Chairman / President / Director / Principal is assigned / assumes the role of Sponsor or Champion depending on the size of the organisation, which is accountable for V&M in Quality Systems. The defined goals are then flown down to department heads, to individuals in chain of implementation to achieve desired goal. A generalised EEE structure for implementation of DMAIC is depicted in Fig. 5. Depending on the size of the EEE and its function Champions, Sponsors and MBB roles can get merged thus performing all the intended function. The broad DMAIC – EEE Structural model is depicted for one department and function to explain how V&M is flown into individual levels towards achievable objectives. This can be extended / expanded / adopted based on various stated V&M or G&O of the EEE.

Though this structure is explained keeping Engineering Educational Enterprise in mind, but adoptable with modifications to any educational environment with suitable modifications as appropriate. As the faculty develops the passion in adopting and leveraging the six sigma approach in their research and academic work, it further flows down into their respective Student and research scholar projects, thus full potential of Six Sigma is realised into the EE enterprise as a whole. This is the way, Motorola, GE and all other great leaders demonstrated success by driving Six Sigma as a DNA of the organisation.

4.4 Typical DMAIC Tools Applicable to EEE Model

Fig. 6 is suggestive in nature of the various tools that could be used in various phases of the DMAIC model in achieving the desired G&O or V&M. It is not a rule that a specific tool has to be used only in that phase as mentioned.





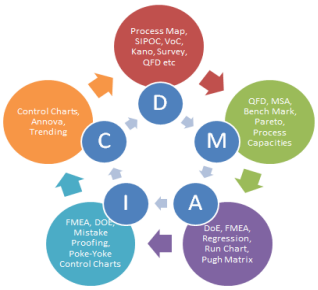


Fig. 4 DMAIC Model for EEE Fig. 5 DMAIC Structural Model for EEE Fig. 6 Tools in DMAIC

4.5 Typical CTQ Flow-Down, Flow-Up for Roles & Responsibilities in a DMAIC Model for EEE

As explained earlier, the Six Sigma success is at the organisation level and hence its deployment requires commitment and engagement at the highest level. A typical engagement of various levels of the organisation and their alignment to Six Sigma role in a frame work for achieving the desired of targets or realistic Goals are captured in Fig. 7. It flows from top level (like system in a product) to the bottom level (like that of a component in a system) in assigning the roles and responsibilities to achieve the quality goals, with achieved goals flowing-up from lowest level to the highest level of the system. A typical example is captured what could be achieved at the each phase at various level for the given cause / target from top level and what can be achieved at next levels as it flows down to the level like that of a System in a product to component. This explains the CTQ (Critical to Quality) flow down from System level to component / part level. It also explains how the quality rigour is achieved in component / part level and is flown back to build the Quality rigour into the system with the broad structure of roles and responsibilities and mapping it to the DMAIC – EEE Structure. It is a typical example and has to be altered based on the CTQ at the Institution level which is comparable to that of a system and to the Departments comparable with that of a sub-system and to the individuals of the Institution comparable to that of a part / component level quality.

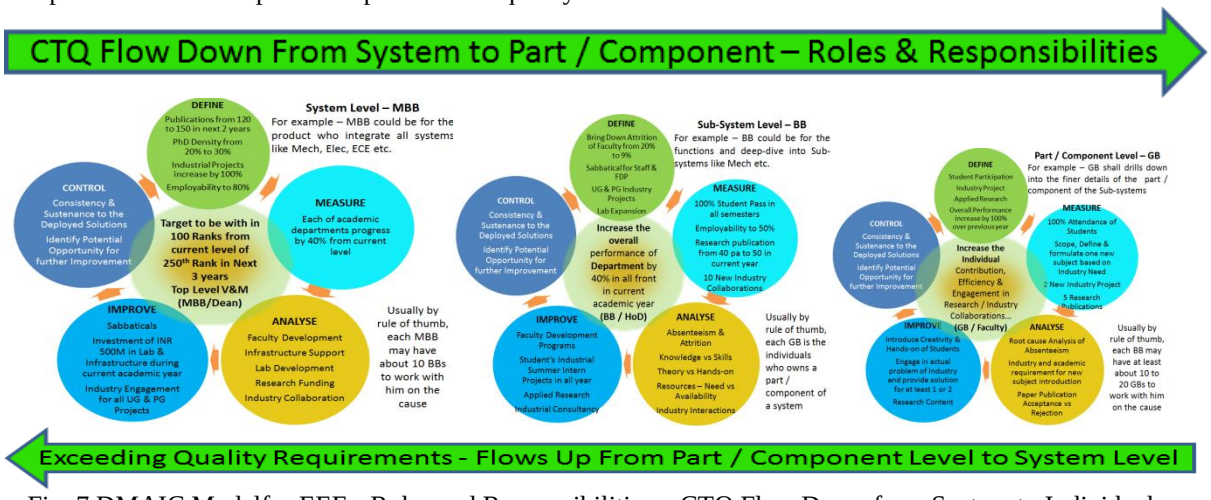


Fig. 7 DMAIC Modelfor EEE - Roles and Responsibilities – CTQ Flow Down from System to Individual vs Achievement of Quality from Individual to System

V. SCOPE FOR FURTHER WORK:

The structure of the DMAIC for the EEE has been structured and formulated. Each of the phase and the complexity with the applicable tools along with the case study are dealt separately in the future publications. It has also been included to bring-out how to merge DMAIC Frame work proposed in this work can be merged with ISO Standards adopted by the EEE, thus avoiding / repeating administrative work. DFSS model for the institutions which has the opportunity to introduce new papers / courses are dealt separately in future work.

VI. SUMMARY AND CONCLUSION:

From the literatures surveyed and referenced, broader structural frame work of a DMAIC Model for EEE with Organisation Structure, applicable tools and assignable roles and responsibilities has been delivered.

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