Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 4 (2023)

Review on Lean Six Sigma in Higher Education

[1]Nitesh Haridas Chahande, [2]Dr. Girish V. Thakre,

[1].Research Scholar, Department of Mechanical Engineering, Bapurao Deshmukh College of Engineering, Sevagram, Wardha

[2]Professor, Department of Mechanical Engineering, Bapurao Deshmukh College of Engineering, Sevagram, Wardha

Abstract

Service sector accounts for a substantial share in Indian economy and among the service industries, education sector is emerging as a major commercial activity in the nation. Globalization, growingcompetition among institutions, emergence of new technologies, changing socio-economic profiles ofnations and knowledge driven economies have created a scenario where quality in education isbeginning to occupy the centre stage. Now the quality is no more a desirable strategy – it has become asurvival strategy. In such a scenario, 'Technical Education Institutions' require an innovativesupporting tool, which helps in improving the quality of education system.

As there is no such model available for assessing the performance of engineering colleges using lean six sigma metrics, this work will help to identify the performance of each & every department of the engineering colleges. We are trying to develop a performance model for engineering collegesby using lean six sigma metrics by applying various tools of lean six sigma. Then we will check the reliability &validity of a performance model after conducting the case studies in various engineering colleges. Research methodology will be used to accomplish the set objectives by finding the various lean six sigma metrics, finding the various departments in the engineering colleges, applying various tools of lean six sigma, developing a performance model for engineering colleges by using lean six sigma metrics. After that checking the validity and reliability of a performance model and finally conducting the case study in various engineering colleges.In this work we are going to develop a performance model for engineering colleges using lean six sigma metrics which will help the engineering colleges to measure the performance of their respective institute.

1. Literature Review

The exhaustive literature review is carried out on the topic performance model for engineering colleges using lean six sigma metrics. The contribution of various researchers is presented below:

In their 2008 study, Anil R. Sahu, Dr. R. L. Shrivastava, and Dr. R. R. Shrivastava classified the many elements that impact the efficacy of technical education into seven broad categories. To evaluate efficacy according to these criteria, a mathematical model has been developed. The suggested approach provides a very accurate means of calculating the efficacy of a technical institution.

Research conducted by Debaprayag Chaudhuri, Sadhan kumar Ghosh, and Arup Ranjan Mukhopadhyay (2010) used a survey questionnaire to assess the existing or baseline performance level of the engineering departments at the Indian Institute of Technology, Kanpur. The survey form has been thoughtfully designed to gather input from both the service providers (administrators, faculty, and other support personnel) and the actual consumers (students) of these services. We have polled 116 people across all six divisions. The eight enablers that make up

the survey questionnaire were quantified in order to determine the departments' baseline or present performance level in relation to the sigma level.

Sadhan Kumar Ghosh, Debaprayag Chaudhuri, and Arup Ranjan Mukhopadhyay (2011) Enabler: Placement facilitates campus recruiting. The payment was not as expected (Enabler: Placement). Here's why. Faculty and research academics' absence of patents, prizes, and doctoral degrees (Enabler: Innovation/Research Activities). Enabler: Academic Administration reports an unsuitable student-teacher ratio compared to the standard set by the All India Council for Technical Education. (Class time for theoretical lectures: 60:1, for tutorials: 15-20, for lab work, workshops, and drawings: 15:1, and for projects: 9:1). . Inadequate faculty feedback mechanism on student weaknesses (Enabler: Faculties). When it comes to the following, faculties are lacking: familiarity with the field. - Expressing oneself. - Information exchange. - Reviewing recorded responses. - Enabler: Faculties ensure timely review of response scripts. If private colleges can adopt the necessary corrective measures in the aforementioned areas, they can become more competitive with public engineering schools. By addressing the highlighted areas of weakness in Table IX, it is feasible for all institutions, whether public and private, to reach the benchmark sigma level listed in Table VI. You may find the potential corrective actions in Table X. Of all the engineering colleges in India, Kharagpur's IIT is by far the best. Students from all throughout the world, including India, are welcome to apply. Another world-famous engineering university is Kharagpur's IIT. Its benchmark sigma level is3.43, whereas its baseline sigma level is2.19. As a result, it ranks ninth in this study. Beyond Institute of Engineering & Management, Salt Lake, Kolkata, there is an even wider disparity between the two sets of data. According to our results, the best college in Kolkata is the Institute of Engineering & Management in Salt Lake.

In contrast to the expansion of technical education, Dr. C. C. Handa (2011) stressed the importance of research and its need. The causes for the absence of cult, indifference towards science, and its implementation are being sought after. There are recognized obstacles to the expansion of research activities at the institutional level. An earnest effort is made to gather solutions and provide inspiration for promoting basic and applied research at the level of scientific and technology institutes. Additionally, a SWOT analysis method was proposed.

According to Sivajothi Paramasivama and Kanesan Muthusamy (2012), the DMAIC approach is recommended in this research because to the many favorable evaluations it has received about its capabilities. Additionally, an effort has been made to link this widely used corporate practice with the academic context of an undergraduate engineering curriculum. The goal here is to prevent universities from straying from their original mission of educating creative problem solvers in pursuit of financial gain.

The six sigma approach has been seeing meteoric rise in popularity and effective application in recent years, according to Javad Mehrabi (2012). Many companies that are driven by technology and projects are seeing it as a key motivator. Skills in project management and control, organizational commitment and engagement from upper management, the ability to effect cultural change, and ongoing training are all factors that contribute to six sigma project success. It is possible for practitioners to better execute six sigma projects if they have a good grasp of the methodology's essential characteristics, challenges, and limitations. This study traces the history, advantages, and disadvantages of six sigma methods and pinpoints the critical success elements for implementing six sigma projects. It incorporates the knowledge gained from six sigma initiatives that were successful and takes into account ways the methodology might be improved upon. The culture of a company must be continually fine-tuned for six sigma concepts and practices to be effective. Before a cultural shift can be firmly established in a company, it takes time and dedication. The most popular definition of education quality is the degree to which a school or district is successful in imparting the commonly held beliefs and values that students should leave with a better understanding of the world and the ability to think critically and creatively. Organizational managers often dealing with education and quality may benefit from our conceptual framework's fresh insights.A potential framework that addresses sustained quality improvements at technical institutions might be based on the important aspects of total quality management (TQM) outlined by Anil R. Sahu et. al. (2013). This could be a way to apply TQM in higher education programs. This study is grounded in theory and practice thanks to a literature review of TQM and associated quality approaches and an examination of the

content of TQM literature in technical institutions. In order to identify important variables for implementation, the content analysis was conducted using established principles of deductive reasoning. To be effectively implemented at technical colleges, TQM concepts must be adapted differently from how they are in industry. Technical universities and colleges may benefit greatly from the detailed guidelines for implementing TQM that are based on the recognized essential components of TQM and associated quality improvement approaches. If technical institutions want to fix their quality problems, this article lays out the key components of effective quality improvement programs. Academics may use the study's important components as a road map to use TQM at technical institutes, and they can use them to outline a mathematical model specific to these institutions.Using factor analysis,

Anil R. Sahu, Rashmi R. Shrivastava, and R.L. Shrivastava (2013) aimed to determine which CSFs are used in quality management programs for technical education and put forth seven of them. Empirical investigation confirmed the stated measures to be true. With a reliability coefficient (alpha) of 0.95, which is higher than the adequate threshold of 0.7, and with each variable having a communality value more than 0.60 (a measure of "uniqueness"), the first set of 72 items was adequately selected. Technical institutions may use this tool to find out how their staff feels about the education they get there. Thorough pre-testing and a rigorous literature review proved its content, criteria, concept, and convergent validity. According to the study's findings, the seven critical success factors (CSFs) that need to be addressed for technical education to reach its full potential are as follows: improvement of infrastructure, capacity building, involvement of top management, networking and collaboration, innovation, quality culture creation, and continuous improvement. More research on quality-related issues and TQM implementation is expected to be stimulated by the proposed research instrument, which is necessary for technical education excellence.Six Sigma originated in the industrial sector/

According to M. Vijaya Sunder (2014), the approach was adjusted for use in the service industry. Higher education institutions need a more methodical approach to use Six Sigma in the education sector. For organizations looking to launch Six Sigma initiatives, the proposed approach serves as a blueprint. Simultaneously, the proposed framework acknowledges the value of practical learning experiences. Thus, the proposed framework not only supports an integrated education system but also ensures that students have a strong grounding in practical and application-based knowledge, which is essential from a professional perspective. The backing of university administration is crucial to the implementation of this strategy. It should be noted that not all educators are receptive to new ideas or are prepared to evaluate their practices using TQM or Six Sigma tools. This approach works well if you want to improve the campus's facilities or services. Class schedules and debates are academic institutional processes that are heavily influenced by course, nation, university, and board of education regulations. The model as it stands does not effectively address these areas. Lean Six Sigma (LSS) is a powerful process excellence technique that combines the principles of Lean and Six Sigma (Jiju Antony, 2015). The application of LSS to the HES is an emerging field, but it will emerge as a hot topic in the next years. Many hurdles have prevented a comprehensive investigation of LSS's potential in academic processes, despite its use in many HE administrative, financial, estate, HR, and library activities. A combination of Lean and Six Sigma methodologies might help higher education institutions optimize their business operations by identifying and eliminating process variance-causing flaws and defects. This article discusses some of the most fundamental challenges that might arise when trying to use LSS in a higher education setting. These issues have been raised by eminent LSS researchers and practitioners from three separate continents. The study's findings could be very useful for those who are trying to make HE procedures more efficient and effective by using LSS ideas.

The LSS program was able to demonstrate its worth to the company by enhancing business processes and facilitating the university's operational efficiency, as noted by Carsten Svensson, Jiju Antony, Mohamed Ba-Essa and Majed Bakhsh & Saja Albliwi (2015). Projects that were completed successfully not only demonstrated the value of LSS to persons and process owners, but also inspired other process owners to implement similar initiatives in their own domains. Consequently, project requests have been coming in more often at the green belt and black belt levels. There have been over forty new projects started this year that

address various business processes within the institution. These initiatives encompass sectors including IT, HR, and finance.

It is premature to say if the effort was successful or not, according to Dong-Suk Kim (2016), as just two years had passed since implementation began. Despite the fact that Six Sigma increases their workload, the librarians expressed favorable thoughts regarding its impact throughout the focus group interviews. Researchers who have doubts about Six Sigma's suitability for libraries and other non-profit service organizations might get a fresh viewpoint from this study, which is important since it aims to identify particular success factors. To get better results from the improvement project that we do every semester, we have to zero in on each success component.

Although there aren't many instances of six sigma application in academia, Lawrence O. Jenicke, Anil Kumar, and Monica C. Holmes (2016) shown that it is feasible to employ this technique for improvement. We began by cataloguing the obstacles to six sigma implementation in the academic sector, and we conclude with a proposal for a framework that may serve as a guide for such an endeavor. Everyone involved in an educational setting may benefit from this approach, including students, teachers, and administrators. The framework makes it clear to all parties involved what the goal is of using the technique. It is important to note that senior management plays a pivotal role in the effective implementation of six sigma. Academic institutions, like businesses, need senior leadership to take the lead in implementing six sigma. The implementation's rationale, stakeholder expectations, and expected outcomes must be communicated effectively by top management. The effectiveness of the process depends on the stakeholders' openness and engagement throughout. Even if a university president may not have the time to complete six sigma training, the heads of individual departments and colleges might serve as role models by doing so. Staff will be more motivated to take part in training as a result of this.

In an effort to determine the talents engineering graduates have that employers value, Vijay N. Kalbande et al. (2016) conducted a study. We evaluate the abilities that impact the success of engineering graduates in campus placement. Utilizing statistical methods like the chi-square test and the T-Test in SPSS-20, this research identifies and correlates a number of talents. We created a mathematical model using binary logistic regression to forecast the likelihood of engineering graduates being hired by international IT businesses during their campus placement recruiting processes. In order to determine the effect of input factors such as aptitude, communication, technical, and personality skills on employability, a sensitivity analysis was conducted. To gain early job in the company's campus placement recruiting procedure, aptitude is the primary determining ability.

To increase administrative efficiency and the overall quality of the education that students get, Sylvie Nadeau (2017) compiles the recorded experiences of universities with implementation of lean, six sigma, and lean six sigma methodologies from 2000 to 2016. We catalogued the interventions' aims, the schools most dedicated to implementing this strategy, the methods most often used, the results (when given), and the difficulties that were faced. So far, we have shown that lean, six sigma, and lean six sigma philosophies are very new to university settings and have only been adopted locally inside the complex systems that are being studied. Appropriate client definition, added value, and the relationships between research and education are a few of the obstacles to their effective implementation. A number of potential solutions to these problems have been put up.

The feasibility and execution of Lean Six Sigma (LSS) at HEIs were studied by Vijaya Sunder M. and Sanjay Mahalingam (2017). LSS is the newest service quality technique that has been successful in both the manufacturing and service industries. There seems to be a lack of data about the deployment of LSS in HEIs, despite the abundance of literature on the use and advantages of LSS in service industries (such as banking, healthcare, and the IT industry, among others). We follow a five-stage process. This research uses a multiple case-study approach to investigate this LSS implementation at two chosen foreign university institutions. The projects are carried out using the LSS toolkit, which consists of the stages define, measure, analyze, improve, and control. The technique is made more interesting by including student teams in LSS project management.

The key success factors (CSFs) and basic obstacles of developing a Lean Six Sigma (LSS) strategy in a UK HEI were investigated by Jiju Antony et al., (2017). In addition to outlining some of the most important takeaways from the LSS experience, the paper provides samples of the many projects that were finished. At the outset, the

writers combed through the current corpus of literature on LSS in higher education applications to get a feel for the breadth and depth of previous research in the area. Next, we'll take a look at a case study that explains how one UK higher education institution has started using LSS as a process excellence approach to boost the efficiency and effectiveness of its core and supporting functions.

According to Stephen Anthony and Jiju Antony (2017), this strategy is necessary since UK universities still seem to be far from becoming Lean or Six Sigma. The ability to examine and improve any business process is a key component of Lean Six Sigma. In order for educational institutions to be certified as Lean Six Sigma, they must embrace teaching and research as well as administration. At end, the heads of departments and our universities are the only people inside an institution who can bring about this kind of cultural shift. For example? Teachers in the United Kingdom? Who are the UK's vice principals? American University Chancellors?

Although Lean has been a fantastic quality excellence technique for success in HEIs, Vijaya Sunder M. and Jiju Antony (2018) noted that LSS successfully tackles Lean's weaknesses. In the services industry, LSS has been more effective than Lean alone as a hybrid technique. As a management approach for quality excellence, the synergies that Lean and Six Sigma bring together provide a powerful arsenal for enhancing service quality. We must acknowledge that LSS has drawn several academic scholars in addition to its successful application in the practitioner community. Research on LSS's use in HEIs, however, is still in its infancy. This study provides more evidence that LSS may be useful in HEIs and develops the topic further by way of a conceptual model. Academics and HEI practitioners alike will find this study innovative since it provides a formal framework for implementing LSS in a HEI environment, which is currently unavailable in refereed publications. When implementing LSS at a higher education institution (HEI), it is recommended to consider not only the academic and instructional processes and systems, but also the administrative procedures of the institution. One standout feature of the suggested framework is the emphasis it places on student agency and participation in the LSS rollout. The fact that HEI's plan is in sync with the LSS strategy is another noteworthy aspect. Additionally, it is crucial to conduct a readiness assessment at HEIs prior to implementing LSS. This research proposes a conceptual model for LSS deployment that is tailored to HEIs and consists of six stages. A key component of every leadership agenda should be the implementation and maintenance of LSS. Leadership "position" is a key component in the success or failure of any change management program, including LSS. Moreover, when leadership is seen as encompassing more than just their role, it motivates other stakeholders to get involved.

Sandeep Kumar Gupta et al. (2018) conducted research into the reasons why students leave HEIs and looked at how Lean Six Sigma (LSS) methods may be used to lower dropout rates. The intricacy of the student dropout phenomena and the function of different LSS techniques in lowering dropout rates were explored in this qualitative research using 12 semi-structured interviews with university personnel (n = 9) and LSS specialists (n = 3). In order to create a classification system for student dropouts, research shows that higher education institutions need to keep meticulous records and raise awareness among the appropriate authorities on the consequences of a student's choice to drop out. Officials at HEIs and LSS specialists have provided fresh motivation to examine and address the problem of student dropouts, despite the study's limited number of semi-structured interviews.

Implementing the LSS define-measure-analyze-improve-control framework in a field-setting at a higher education institution (HEI) was the subject of an investigation by Milad Haerizadeh and Vijaya Sunder M. (2018), who used a case study approach to demonstrate the theory in action. The study aimed to highlight the subsequent challenges that occurred and the lessons learned from these experiences. The most important thing that came out of the study was that LSS can be used in education systems. The LSS team had a few goals: they wanted to improve the overall rating by 10%, lower student advising wait times by 15%, and increase enrollment by 5%. By using LSS methodology, they were able to achieve these goals, which shows that the university's education system is improving. Additionally, LSS has shown that the school system is better for students as a result of its deployment.

By utilizing various literature constructs such as Total Quality Management (TQM), Lean, Six Sigma, and Lean Six Sigma (LSS), Vijaya Sunder M. and Jiju Antony (2018) sought to demonstrate the powerful use of Lean Six Sigma (LSS) in HEIs, propose a conceptual framework for implementing LSS in HEIs, and emphasize the significance of the Quality Excellence criterion in general. This study delves deeper into the topic of LSS's potential use in higher education institutions (HEIs), arguing that these institutions are fundamentally different from the industrial sector, from whence LSS first emerged. A conceptual framework for LSS deployment at HEIs was developed using published literature on LSS and the authors' experience as practitioners in the area. The study's primary conclusion was the confirmation of LSS's applicability in HEIs. The report also shows that LSS is an important aspect of leadership's agenda, not someone's job. An important takeaway from this research is the six-stage conceptual framework that the authors recommend to HEIs. The model explains that HEIs should prioritize LSSreadiness as the first step in deploying LSS. In order to attain the long-term goals of achieving quality excellence as an organization, top-down leadership must first recognize the need for LSS. The next stage is to plan the rollout of LSS. The next crucial phases in implementing LSS are educating the right stakeholders (the kids) and forming a team. Finding and executing LSS projects becomes crucial when the aforementioned procedures are correctly executed. Quality Excellence in Higher Education Institutions is attained via the successful completion of LSS projects. In this paper, Na Li and Chad Matthew Laux (2019) use a case study approach to show how a higher education institution (HEI) improved their service processes by implementing lean Six Sigma (LSS). They also detail the difficulties they faced and the lessons they learned along the way.

Higher education's use of TQM approaches with Six Sigma and Lean Six Sigma was considered by H. J. Brits (2018). Within the context of higher education, it explores the potential for using its approaches to improve procedures, decrease waste, and boost satisfaction and profit. Continuous improvement, cost and waste reduction, and customer satisfaction may be achieved via the structured approaches offered by TQM and its integration with Six Sigma and Lean Six Sigma. The higher education sector has been predicted that TQM's missionary appeal has diminished, but by integrating Six Sigma and Lean Six Sigma with TQM, this may be revived. A top-down approach including senior management's demonstration of their commitment to the principle of continual improvement and waste reduction was necessary, as was sound planning and an integrated strategy.

In their 2018 study, Elizabeth A. Cudney, Sri Sandilya Jeemooth Venuthurumilli, Tejaswi Materla, and Jiju Antony assessed the efficacy of Six Sigma and Lean concepts in the context of higher education. To combat the challenges posed by falling income and productivity, universities should actively seek out Lean Six Sigma's advantages, say Bandyopadhyay and Lichtman (2007). The implementation of Six Sigma and Lean principles in the creation of course offerings at higher education institutions was the primary emphasis of this study. In order to raise the bar for university education, this article explored several Six Sigma and Lean implementations. When it came to using the Lean Six Sigma methodology to increase efficiency and effectiveness in higher education, no one model or strategy had universal support. To increase education quality without going overboard on expenses, it is necessary to use Six Sigma and Lean techniques, which are difficult and need competent persons to execute (Cudney et al., 2014). Academic management, student happiness, and academic achievement may all be enhanced by implementing a system that makes use of Lean and Six Sigma principles.

In their 2019 article, Janelle Margaret Davidson et al. discussed the literature study that looked at quality frameworks in HE. Quality frameworks ensure that pupils are taught and learn to a minimal level. The methods and resources needed to enhance the foundational structures and processes of education are highlighted in this literature review. Keeping this in mind, the authors show how the HE sector has embraced Lean Six Sigma (LSS) as a technique for improvement and discuss what variables help or hurt HEIs when trying to use LSS.

According to Iman Adeinat, Naseem Al Rahahleh, and Tameem Al Bassam (2021), the DMAIC framework has the potential to be very useful for controlling and progressing the Assurance of Learning process. Crucial steps in enhancing the Assurance of Learning process included creating a project charter, outlining the process using

the SIPOC model, and using a variety of LSS tools and methodologies for assessment measurement and management.

The following table shows the findings of the literature review:

Name of Author / Authors	Name of journal & Title	Year of publication	Findings
Anil R. Sahu , Dr R. L. Shrivastava, Dr R. R. Shrivastava	"Key Factors Affecting the Effectiveness of Technical Education– An Indian Perspective", Proceedings of the World Congress on Engineering 2008 Vol II WCE 2008, July 2 - 4, 2008, London, U.K.	2008	Examined the numerous aspects which impact the efficacy of technical education and have divided them into seven key categories. A mathematical model was developed to evaluate the efficacy according to these criteria. To accurately measure the efficacy of a technical institution, one might use the suggested model.
Debaprayag Chaudhuri, Sadhan kumar Ghosh, Arup Ranjan Mukhopadhyay	"Assessment of the engineering departments of Indian Institute of Technology, Kanpur through application of six sigma metrics", i-manager's Journal on Management, Vol. 5lNo. 2 lSeptember - November 2010	2010	Worked on the basis of survey questionnaire in the Engineering departments (under graduate) of Indian Institute of Technology, Kanpur to measure the current or baseline departmental performance level. The feedback for this survey questionnaire has been considered independently for service providers such as administrators, faculties, other supporting staff as well as students who receive these services and are direct customers. Ccurrent performance level of the departments had been assessed based on the sigma level through quantification of the survey questionnaire consisting of eight enablers.
Debaprayag Chaudhuri, Arup Ranjan Mukhopadhyay, Sadhan Kumar Ghosh	"Assessment of engineering colleges through application of the Six Sigma metrics in a State of India", International Journal of Quality & Reliability Management, Vol. 28, pp. 969 - 1001	2011	Campus recruitment or placement (Enabler: Placement). . Remuneration not as per expectation (Enabler: Placement). Lack of patents, awards, PhDs by faculties or research scholars (Enabler: Innovation/Research Activities). . Inappropriate student-teacher ratio that differs from the All India Council for Technical Education norm (Enabler: Academic Administration).
Dr. C. C. Handa	"Research activity in un-aided engineering colleges a review, need	2011	Author had made an attempt to emphasis the need & growth of research activity in

	& hurdles", The Journal of Engineering Education July & October.		comparison to the growth of technical education. An effort is made towards identifying the reasons for lack of cult, apathy for research and its application.
Sivajothi Paramasivama & Kanesan Muthusamy	"Study of Critical Success Factors in Engineering Education Curriculum Development Using Six-Sigma Methodology", International Conference on Teaching and Learning in Higher Education (ICTLHE 2012) in conjunction with RCEE & RHED 2012	2012	The purpose of this research was to investigate the potential connections between this widely used strategy in industry and the parameters of an undergraduate engineering curriculum. This is to prevent universities from straying from their mission of educating creative problem solvers and instead focus on making a profit.
Javad Mehrabi	"Application of six-sigma in educational quality management", Procedia - Social and Behavioral Sciences 47 (2012) 1358 – 1362	2012	Detailed how the company's culture may be fine-tuned in a constant effort to implement six sigma concepts. The most popular definition of education quality is the degree to which a school or district is successful in imparting the commonly held beliefs and values that students should leave with a better understanding of the world and the ability to think critically and creatively. Managers at companies that deal with excellent education and training might benefit from this conceptual framework's new ideas.
Anil R. Sahu, Rashmi R. Shrivastava, R.L . Shrivastava	"Critical success factors for sustainable improvement in technical education excellence: A literature review", at The TQM Journal Vol. 25 No. 1, 2013 pp. 62-74	2013	To be effectively implemented at technical colleges, TQM concepts must be adapted differently from how they are in industry. A thorough guidance for the efficient and successful implementation of TQM at technical institutions is provided by the recognized important elements of TQM and related quality improvement approaches.
Anil R. Sahu, Rashmi R. Shrivastava & R.L. Shrivastava	"Development and validation of an instrument for measuring critical success factors (CSFs) of technical education – a TQM approach" International Journal of Productivity and Quality Management, Vol. 11, No. 1, 2013	2013	The seven dimensions have been described in detail, and the most crucial CSFs to investigate in order to attain technical education excellence are infrastructure development, capacity building initiatives, involvement of upper management, networking and collaboration, innovation efforts, continual improvement, and quality culture creation. To achieve excellence in technical education, the suggested

			research instrument was to serve as a springboard for further studies investigating quality-related problems and TQM's application.
M. Vijaya Sunder	"Quality excellence in higher education system through Six Sigma: student team engagement model", Int. J. Six Sigma and Competitive Advantage, Vol. 8, Nos. 3/4, 2014	2014	In order to implement Six Sigma programs on campus, the suggested model provides a framework that colleges might use. Therefore, the suggested framework does double duty: it promotes an integrated education system and equips students with the wealth of practical, application-based knowledge that is crucial from a professional standpoint. Course, nation, university, and board of education regulations determine how the model should be used to enhance academic institutional procedures such as class schedules and debates..
Jiju Antony	"Challenges in the deployment of LSS in the higher education sector Viewpoints from leading academics and practitioners", International Journal of Productivity and Performance Management Vol. 64 No. 6, 2015 pp. 893-899	2015	Addressed some of the basic issues in the implementation of LSS in a HE scenario. Prominent LSS scholars and practitioners from three different continents have put forward these problems. Individuals engaged in using LSS concepts to enhance the efficacy and efficiency of HE processes may find the study's conclusions to be very beneficial.
Carsten Svensson, Jiju Antony, Mohamed Ba-Essa and Majed Bakhsh & Saja Albliwi	"A Lean Six Sigma program in higher education", International Journal of Quality & Reliability Management Vol. 32 No. 9, 2015 pp. 951-969.	2015	By streamlining operations and enhancing business processes, the LSS initiative demonstrated its worth to the company. Projects that were completed successfully not only demonstrated the value of LSS to persons and process owners, but also inspired other process owners to implement similar initiatives in their own domains.
Dong-Suk Kim	"Eliciting success factors of applying Six Sigma in an academic library A case study", Performance Measurement and Metrics Vol. 11 No. 1, 2010 pp. 25-38 Emerald Group Publishing Limited	2016	This study's effort to elicit particular success characteristics is significant because it allows researchers to approach the difficulties with a different viewpoint, which is helpful for those who wonder whether Six Sigma is acceptable for non-profit service companies, like libraries. So, to get the most out of the improvement project we

			do every semester, we need to pay close attention to each success aspect..
Lawrence O. Jenicke, Anil Kumar and Monica C. Holmes	"A framework for applying six sigma improvement methodology in an academic environment", The TQM Journal Vol. 20 No. 5, 2008 pp. 453-462 Emerald Group Publishing Limited 1754-2731	2016	Proved that six sigma could be used for improvement, even if there were few instances of its use in academics. After outlining the obstacles to six sigma implementation in academia, they provide a structure that institutions may follow as a guide to adopt the methodology. In terms of the goal of applying the approach, the framework makes it clear to the stakeholders.
Vijay N. Kalbande, Chandrahas C. Handa, Amit W. Bankar	"Binary Logistics Regression Analysis to Assess Employability of Engineering Graduates in IT sector", Smart Technologies for Energy, Environment and sustainable Development pp 673-682.	2016	In order to forecast the likelihood of engineering graduates being hired by global IT corporations throughout their campus placement recruiting processes, a binary logistic regression model was created.
Sylvie Nadeau	"Lean, Six Sigma and Lean Six Sigma in Higher Education: A Review of Experiences around the World", American Journal of Industrial and Business Management, 7, 591-603.	2017	In order to increase administrative efficiency and the overall quality of the education that students get, this research compiles the recorded experiences of universities that used lean, six sigma, and lean six sigma methodologies from 2000 to 2016. He detailed the interventions' aims, the schools most dedicated to using this strategy, the methods most often used, the results (when given), and the difficulties that had to be overcome. A number of obstacles prevent their effective implementation, such as a clear understanding of the customer, the concept of value addition, and the relationships between academia and industry.
Vijaya Sunder M. & Sanjay Mahalingam	"An empirical investigation of implementing Lean Six Sigma in Higher Education Institutions", International Journal of Quality & Reliability Management, Vol. 35 No. 10, 2018 pp. 2157-2180.	2017	Despite the abundance of material on the topic of LSS's advantages and applications in other service sectors, it seems that no proof of its deployment in HEIs can be found in the existing literature.
Jiju Antony, Abhijeet Ghadge, Stephanie A Ashby and Elizabeth A.	"Lean Six Sigma Journey in a UK Higher Education Institute: A Case Study", International Journal of	2017	Investigated the main obstacles and CSFs in establishing a Lean Six Sigma (LSS) program at a UK HEI.

Cudney	Quality & Reliability Management		
Stephen Anthony, Jiju Antony,	"Lean Six Sigma in Academic Institutions—UK vs. Rest of the World", 4th International conference on lean six sigma for higher education, May 25–26, 2017	2017	This methodology is much-needed, since UK universities still seem to be far from becoming Lean or Six Sigma, as you so eloquently put it. Any business process may be examined and improved according to Lean Six Sigma principles; thus, educational institutions cannot attain Lean Six Sigma status unless they include research and teaching into their practices.
Vijaya Sunder M., Jiju Antony	"A conceptual Lean Six Sigma framework for quality excellence in higher education institutions", International Journal of Quality & Reliability Management, Vol. 35 Issue: 4, pp.857-874	2018	The authors confirm the applicability of LSS in HEIs, and further expand this subject through a conceptual model. Since there was no single structured framework available in the refereed journals on deploying LSS in an HEI setting, this paper adds novelty for both academicians and HEI practitioners. It is also suggested that while deploying LSS, the HEI setting should be looked beyond the teaching/academic processes or systems, but also include administrative processes of the colleges or universities.
Sandeep Kumar Gupta, Jiju Antony, Fabian Lacher & Jacqueline Douglas	"Lean Six Sigma for reducing student dropouts in higher education – an exploratory study", Total Quality Management & Business Excellence, Informa UK Limited, trading as Taylor & Francis Group	2018	Investigated the potential causes behind student dropouts in higher education institutions (HEIs), and explores the use of Lean Six Sigma (LSS) tools in reducing dropout rates.
Milad Haerizadeh & Vijaya Sunder M.	"Impacts of Lean Six Sigma on improving a higher education system: a case study", International Journal of Quality & Reliability Management	2018	Highlighted the subsequent challenges occurred and lessons learned during the implementation in Institutions (HEIs).
Vijaya Sunder M & Jiju Antony	"A conceptual Lean Six Sigma framework for quality excellence in higher education institutions", International Journal of Quality & Reliability Management, Vol. 35 Issue: 4, pp.857-874	2018	was to demonstrate the powerful usage of Lean Six Sigma (LSS) in HEI services and to provide a theoretical framework for implementing LSS in HEIs.
H. J. Brits	"A quest for waste reduction at institutions of higher learning:	2018	Considering how Total Quality Management (TQM) and Six Sigma

	investigating the integration of six sigma and lean six sigma methodologies with total quality management", South African Journal of Higher Education, Volume 32, pages 37–50		(including Lean Six Sigma) may be used to teaching and learning at universities. It looked at how its approaches might be used in the academic setting to boost efficiency, cut down on waste, and satisfy students while making a profit. Integrating Total Quality Management (TQM) with Six Sigma and Lean Six Sigma provides defined procedures that guarantee continuous improvement, reduce costs and waste, and enhance customer satisfaction.
Elizabeth A. Cudney, Sri Sandilya Jeemooth Venuthurumilli, Tejaswi Materla & Jiju Antony	"Systematic review of Lean and Six Sigma approaches in higher education", Total Quality Management, Taylor & Francis Group.	2018	Evaluating Six Sigma and Lean methodologies, two continuous improvement strategies, in the context of higher education was the primary goal of this study. The implementation of Six Sigma and Lean principles in the creation of course offerings at higher education institutions was the primary emphasis of this study. In order to raise the bar for university education, this article explored several Six Sigma and Lean implementations. To make efficient and successful use of the Lean Six Sigma methodology, there was no generally agreed-upon model or strategy for use in the academic sector.
Janelle Margaret Davidson, Oriana Milani Price and Matthew Pepper	"Lean Six Sigma and quality frameworks in higher education – a review of literature", International Journal of Lean Six Sigma.	2019	set out to provide a literature evaluation that takes into account the use of quality frameworks in HE.
Iman Adeinat, Naseem Al Rahahleh, Tameem Al Bassam	"Lean Six Sigma and Assurance of Learning (AoL) in higher education: a case study", International Journal of Quality & Reliability Management Vol. 39 No. 2, 2022 pp. 570-587 © Emerald Publishing Limited	2021	Proposed that the DMAIC model may prove to be an excellent tool for directing and enhancing the Assurance of Learning procedure. Improving the AoL process relied on a number of factors, including project charter drafting, SIPOC model process mapping, and the use of a variety of LSS tools and methods for assessment measurement and control.

2. Research Gap

From the literature review, the following gaps / shortages are identified:

Although they did not specifically address lean six sigma measures, Anil R. Sahu, Rashmi R. Shrivastava, and R.L. Shrivastava (2013) did take into account essential success criteria for achieving excellence in technical education over the long term.

• To forecast the likelihood of hiring engineering graduates through the campus placement recruitment process of multinational IT companies, Vijay N. Kalbande, Chandrahas C. Handa, and Amit W. Bankar (2016) constructed a binary logistic regression mathematical model; however, they did not center their work on lean six sigma metrics.

• According to Vijaya Sunder M. (2017), there is a lot of literature on the advantages and applications of LSS in other service industries, but little proof of its deployment at HEIs.

A wide variety of businesses, including manufacturing, healthcare, and the public sector, have made heavy use of LSS to improve customer attention and save costs. Nevertheless, engineering schools have yet to implement it.

• Metrics-based performance models are not accessible to service sector organizations, especially engineering colleges. • Frameworks have been found to be inadequate due to their emphasis on compliance and lack of incentives for continual development.

• The original intention of the surveys was to identify important success elements in the earlier research. However, there is a lack of data from case studies examining the use of lean six sigma measures in engineering schools.

In light of this, the issue that motivates the current investigation is defined.

3. Problem Identification

Based on the research gap following problems are identified:

- Only Critical success factors for sustainable improvement in technical education excellence is used.
- As there is no such model available for assessing the performance of engineering colleges using lean six sigma metrics, this work will help to measure the performance of each & every department of the engineering colleges.

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