26TH INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
5-6 SEPTEMBER 2024, ASTON UNIVERSITY, BIRMINGHAM, UNITED KINGDOM

TRANSFORMING UNIVERSITY SERVICES: THE EFFICACY OF ENGINEERING LEAN SIX SIGMA TECHNIQUES

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ABSTRACT
This paper explores the transformative impact of employing engineering Lean Six Sigma techniques within the context of a university. The study focuses on an examination of several pilot process improvement projects in various service areas of a university located on the southern coast of the UK. Executed over 18 months, allowing both the implementation of improvements and the subsequent analysis of their effects throughout an academic period. This approach yielded a substantial corpus of quantitative data. The utilisation of key engineering tools such as; Value Stream Mapping, Swim Lanes, and Control Charts, played a pivotal role in streamlining processes. Resulting in, significant reductions in processing steps, leading to process enhancements ranging from 12% to 59%, and, in some instances, achieving 100% completion rates. These improvements were further validated by Value for Money measurements, exhibiting gains from 8% to 50%, although the quantification of these gains, was more challenging in certain projects, due to their unique nature. It was often difficult to define the specific data sources and outputs required in these non-traditional engineering environments. Nonetheless, this study underscores the importance of clear comprehension of the Voice of the Customer and Critical to Quality requirements, with active stakeholder engagement, irrespective of the size or nature of the project. In conclusion, the application of Lean Six Sigma methodologies, beyond traditional engineering realms, proved to be a resounding success. This marks the initial steps in a larger journey, where incremental improvements lay the foundation for growth and a staged shift in organisational culture.

Keywords: Transformation, lean, Six-Sigma, service, improvement

1 INTRODUCTION
Universities, like any other complex organisations, face challenges in delivering efficient and effective services to students, faculty, and staff. In recent years, there has been a growing interest in applying Lean Six Sigma (LSS) methodologies to; optimise processes, improve quality, and enhance overall performance within academic institutions. While traditionally used in manufacturing and engineering sectors, LSS has demonstrated its applicability in various service industries. This paper aims to explore the efficacy of engineering LSS techniques in transforming university services, focusing on pilot process improvement projects, conducted at a university located on the southern coast of the UK.
Thus, seeking to leverage engineering theories as catalysts for regeneration and transformation. Showcasing the versatility of these techniques, and their ability to enrich a broader spectrum of the curriculum, than initially envisioned. Therefore, providing a valuable model, that can be used to expand engineering education within higher education, beyond its traditional technical remit.

2 LITERATURE REVIEW
2.1 What is Lean Six Sigma?
LSS is a combination of two well established techniques; with Lean focusing on reducing waste and Six Sigma focusing on Solving Problems. Li et al [1] state that this combination can be used “to reduce waste, improve flow, reduce variation for improving customer satisfaction.” They continue to explain that it is design “maximizes shareholder value” and “can be a very powerful problem-solving methodology in tracking process inefficiency.” With Alblooshi et al [2] backing this up, explaining that “combining them will result in a powerful tool that can be used for eliminating variation and waste”.

This is then expanded on by Davidson et al [3] in regard to Higher Education, with them focusing on how it is;

> "a powerful continuous improvement methodology that HEIs may leverage to improve administrative, academic and development processes."

The main LSS process used to improve a current process for complex and high-risk problems is Define, Measure, Analyse, Improve, and Control (DMAIC). How important this structured problem-solving process is to "provide preventative and corrective action" was further explored by McDermott et al [4]. With O'Reilly et al [5] explaining how the use of DMAIC and a data-driven approach was a key turning point and Li et al [1] consider it a "breakthrough point".

2.2 Use of LSS in Higher Education Institutions (HEIs)

Furterer et al [6] explains how LSS is gaining traction as an improvement processes HEIs as it allows "collaborate objectively with stakeholders to improve a variety of processes". The importance of this is backed up by Li et al [1] highlighting that;

> "Higher education as an industry faces many challenges that have impacted other sectors: increased cost, a reduction of resource support, declining student base, resulting in an overall context for change."

How this is undertaken can be of significances; O'Reilly et al [5] highlighted that;

> "Linking projects to not only strategic objectives …. but also, to plans to implement this strategy at lower levels proved fundamental to success in the targeted areas."

There is clear evidence of how LSS projects have benefited HEIs; with Furterer et al [5] highlighting how alternative scenarios were developed and tested, that otherwise, would have been too expensive and taken too long. Also, Wheeler-Webb and Furterer [7] being able to reduce time to invoice by 38% and Davidson et al [3] reaping benefits to quality outcomes. Panayiotou and Stergiou [8] sum it up well explaining.

> "The benefits underlined in the cases studied in this paper lead to the inference that LSS can have the positive impact that the theory describes in practice"

Wheeler-Webb and Furterer [7] expanded on this, stating.

> "Although LSS has traditionally been successfully applied to manufacturing environments, this project demonstrated the value of applying LSS in higher education."

2.3 Further LSS work in HEIs required

Even though evidence exists on how LSS can be of great benefit, Li et al [1] points out it.

> "Has not been widely adopted by many universes and colleges due to the traditionally misconception that it is only meant to for manufacturing companies."

It is also highlighted by Panayiotou and Stergiou [8] how low the proportion of papers on LSS produced in Europe is, and that there is a clear need for more LSS publications. Davidson et al [3] found that the majority of projects with HEIs are student-facing or focus on administrative processes "which provides a limited amount of empirical evidence of its use in the sector". They continue that there is a need "to identify contextualised best practices and generate opportunities for benchmarking in the sector." The urge to use LSS, to realise similar gains and improvements, was mirrored by; Li et al [1], Alblooshi et al [2], Davidson et al [3], Furterer et al [6], Wheeler-Webb and Furterer [7] and Bhat et al [9].

3 METHODOLOGIES

The study conducted an analysis of several pilot process improvement projects, undertaken at the university over an 18-month period. This was to provide time for both the implementation of improvements, and the subsequent analysis of their effects, throughout a new academic period. These projects encompassed various service areas, including; student support services, academic services, estates, marketing, sustainability, and human resources. The diversity and scope of options, were carefully assessed to provide a comprehensive overview, and grasp of the viability of embarking on an engineering-style improvement project, within the broader university context. Several potential project charters were submitted to a panel and subjected to comparative analysis. Subsequently, a choice was deliberated upon, to optimise the likelihood of success and comprehension, throughout the research pilot phase. Taking into consideration the most cited LSS requirements, as found in research by Alblooshi et al [2], Figure 1.

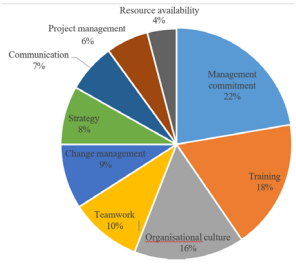

Figure 1. Categories of the requirements of LSS applications

The implementation of engineering LSS techniques, involved the utilisation of key tools, such as; Value Stream Mapping, Swim Lanes, and Control Charts. Data collection methods included quantitative analysis of process metrics, such as; processing times, error rates, and completion rates. Stakeholder engagement and active involvement, were crucial throughout the project lifecycle, to ensure alignment with the Voice of the Customer and Critical to Quality requirements. Each of these projects investigated and used appropriate data collect and sampling strategies, that were applicable to the size and type of the problem, that they were tasked to improve.

4 CASE STUDIES

Of the 12 process improvement projects that were selected for the pilot, due to the page limit constraint, five of the most significant will be used as Case Studies within this paper. That is to provide a clear understanding to the tools used, a rounded picture of achievements, issues and lessons learnt.

4.1 Measuring sustainability in the procurement process

Aligned with the University's strategic plan, which places sustainability as a focal point, this project aimed to integrate sustainability criteria into tenders, for all procurements exceeding £25000. The Voice of the Customer (VoC) methodology was employed to establish a Merit Ranking system for evaluating potential improvements. A before-and-after Swim Lane analysis, depicted in Figure 2, and facilitated by a Gemba Walk for a comprehensive perspective, was utilised to identify areas of waste. The project yielded notable successes, including evident time savings (Figure 2) and a 100% process completion rate (Figure 3). Key insights gleaned from the project, underscored the importance of data clarity in both sourcing and presenting outputs for project success. Additionally, it was recognised that this was just the initial phase, of a broader journey, towards sustainable procurement practices.

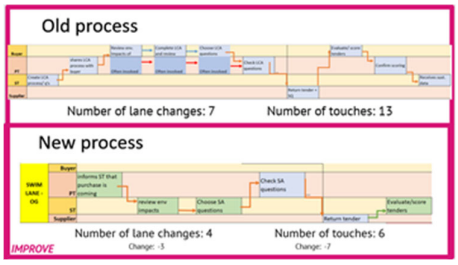

Figure 2. Swim Lanes

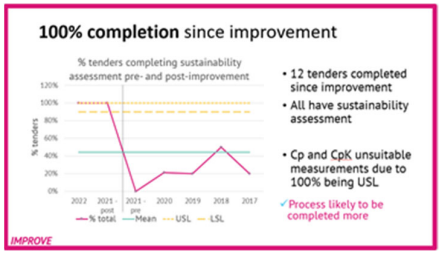

Figure 3. Completion Control Chart

4.2 Reporting and Tracking of Value for Money (VfM) Initiatives

Since 2022, the university has been mandated to fulfil regulatory objectives concerning VfM, and to demonstrate to the Office for Students (OfS), its delivery of value, to students, taxpayers, and the broader community. Non-compliance with these requirements could potentially lead to the loss of millions in grant income. Given the complex nature of this project, the establishment of a Supplier-Input-Process-Output-Customer (SIPOC) diagram, and a Responsible-Accountable-Consulted-Informed (RACI) Assignment Matrix, was essential to gain a clear understanding of the stakeholders involved. Tools such as; the Fishbone diagram, 5 Whys, VoC, and Swim Lanes were employed to define the problem and devise a solution.

Given the project's focus on VfM, conducting a Value-Added Flow Analysis was paramount in crafting a new reporting process, Figure 4, which resulted in an increase of nearly 8%. Due to the project's

complexity and significance, it was imperative to adopt an incremental approach, and ensure its success to cultivate a new LSS culture within the university.

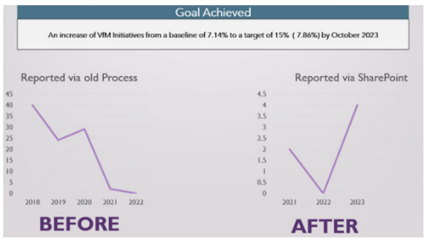

Figure 4. Value for Money

4.3 Reduction of ineligible student appeals and complaints

The process revealed challenges in stakeholder engagement, particularly during the initial stages, suggesting that an alternative approach, from the project's onset, might have been more effective. However, with the guidance of the Project Sponsor, it became feasible to outline the project's scope following initial setbacks. Stakeholder mapping, as illustrated in Figure 5, was subsequently conducted utilising power-interest ranking and a RACI. Further refinement of stakeholder engagement, ensued through a Gemba Walk and Value Stream Mapping (VSM), to identify Value-Added (VA) and Non-Value-Added (NVA) processes, the outcomes, of which, are shown in Figure 6. This was supplemented by a convenience sampling student survey, to comprehensively capture the VoC; as depicted in Figure 7. Leveraging various LSS tools, a solution was devised resulting in a process improvement of 12.07% and a monetary saving exceeding 50% per prospective appeal.

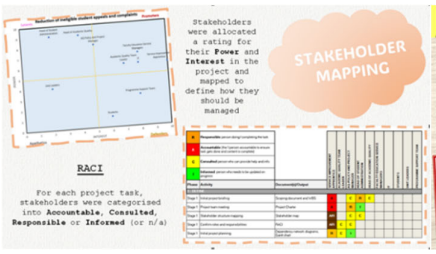

Figure 5. Stakeholder Mapping

Figure 6. Value Stream Mapping

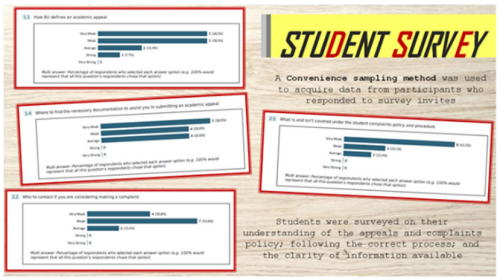

Figure 7. Voice of the Customer

4.4 Estates Contractor Sign in Project

In the project's initial phases, a comprehensive Stakeholder Analysis, Mapping, and RACI were conducted to precisely delineate the problem. The existing state was assessed through a SIPOC analysis, Gemba Walk, and Swim Lane Diagram, with data gathered from a sign-in sheet and analysed to calculate time taken. This analysis resulted in the initial sign-in times (red plot line) and mean value (grey dash line) on the Control Chart, as depicted in Figure 8.

Subsequent data analysis involved utilising a Cause-and-Effect Mind Map, employing the 5 Whys technique, and constructing a Pareto diagram to identify critical inputs. A Force Field analysis, was then employed to identify potential barriers to change, ensuring a smooth implementation process. Figure 8 demonstrates the project's success, evidenced by a notable reduction in sign-in times (green plot line)

and mean value (gold line). The reduction in mean processing time from 4.4 minutes to 2.62 minutes, a decrease of 59%, resulted in an increase in the process sigma value by nearly one level (0.9).

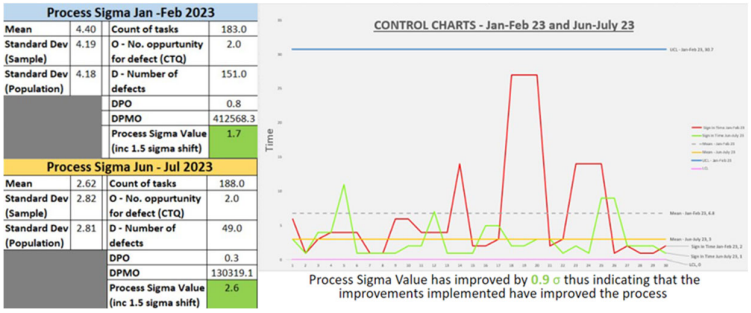

Figure 8. Comparison Control Chart

4.5 Human Resource Management Information Reporting Improvement Plan

However, not all projects have achieved the desired level of success. Some have necessitated extensions beyond the initial pilot phase. As Li et al [1] asserts, "commitment from top management is always a critical success factor for LSS," highlighting the importance of leadership support in LSS initiatives. Additionally, they note that management may sometimes "jump to solutions and conclusions directly instead of following the DMAIC process." This tendency was evident in this project, leading to delays in identifying the true root cause of the problem at hand. Furthermore, this management approach resulted in inadequate project sponsor support, and confusion regarding the identification of the true customer, exacerbating delays and complicating stakeholder engagement issues that persist.

Nevertheless, despite the challenges and competing demands on time, there exists a clear roadmap forward, which is anticipated to facilitate the completion of this project during the second phase of process improvement initiatives. This underscores the importance of addressing management-related issues and ensuring robust stakeholder engagement for the successful execution of LSS projects.

5 RESULTS

The implementation of engineering LSS techniques, within the pilot process improvement projects has yielded notable enhancements across various university service domains. As depicted in Table 1, a comprehensive summary of project process improvements, ranging from 12% to 59% showcases significant progress, with a project achieving 100% completion rates. However, calculating precise VfM measurements posed challenges in certain projects. This is due to their unique data sources and outputs, particularly in the non-traditional engineering environment. This complexity is particularly pronounced in customer-facing service organisations, such as HEIs. Nonetheless, Table 1 provides a summary of results, indicating gains ranging from 8% to over 50%, and up to £23,407/annum, despite these measurement challenges.

Table 1: Summary of Project Process Enhancements and Value for Money Measurements

Project	**Process Enhancements**	**Value for Money Measurements**
Measuring Sustainability in the Procurement Process	100% process completion	£357/annum
Reporting and Tracking of Value for Money (VfM) Initiatives	45.5%	7.86%
Reduction of Ineligible Student Appeals and Complaints	12.07%	50% +
Estates Contractor Sign in Project	59%	£3.8k/annum
Human Resource Management Information Reporting Improvement Plan	Not yet compete	Not yet compete
Website Creation: Time Reduction	34%	£940.30/website
Automation of Right to Work Checks	56%	£23,407/annum
Exploring the Effectiveness of Current Mental Health & Wellbeing Support	49%	Hard to quantify due to nature of project
Improving efficiency in Placements Booking Process	52%	£1400/annum

Policy Influence: Volume, Quality and Effectiveness	16% in engagement 28% in outputs	Hard to quantify due to nature of project
Timetable Data Gathering	48%	£2,380/annum
Reduce the Time Spent on Completing the Fees Reconciliation	36.6%	£805/annum

6 DISCUSSIONS AND CONCLUSIONS

The findings of this study underscores the effectiveness of engineering LSS techniques in transforming university services. By streamlining processes and enhancing quality, LSS methodologies have contributed to improving the student experience, reducing operational costs, and fostering a culture of continuous improvement within the university. The importance of stakeholder engagement and clear comprehension of customer requirements cannot be overstated, regardless of the size or nature of the project. It was something that caused issues and delays in nearly all the polit projects, to a greater or lesser extent.

In conclusion, the application of engineering LSS techniques has proven to be a resounding success in transforming university services. This marks the initial steps in a larger journey towards organisational excellence, where incremental improvements lay the foundation for growth and a staged shift in organisational culture. It is often very difficult to prove a change in organisational culture, however, demonstrating that LSS has be successful in these projects, means it could clearly be tested in other contexts. Moving forward, universities must continue to embrace LSS methodologies to drive innovation, efficiency, and excellence in service delivery. Crucially, fostering a culture that encourages open communication and thorough problem definition before solution implementation will be pivotal.

Future endeavours, already agreed upon, include embarking on a second phase of process improvement initiatives. These endeavours are expected to; elevate the visibility of LSS, propagate its success stories, and enhance stakeholder engagement. Additionally, the initial project leaders will assume the role of LSS Champions, facilitating workshops and developing training programs, to deepen understanding and adoption of LSS principles. This approach aligns with the LSS philosophy of starting small and leveraging successes to nurture a culture of continuous improvement, within the university setting. Through these concerted efforts, a robust LSS culture is anticipated to take root and flourish, driving sustained enhancement across university operation efficacy.

This paper gives a clear demonstration of how an engineering process can act as catalyst for regeneration and transformation for strategic and cultural improvements throughout an established HEI.

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