Implementing Lean Six Sigma into curriculum design and delivery – a case study in higher education

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Abstract

Purpose – The purpose of this paper is to propose the development and adoption of a Lean Six Sigma Framework (LSSF) that attempts to create a more balanced and integrated approach between Lean and Six Sigma and one that is capable of achieving improved efficacy of curriculum and programme development in a higher education environment. The implementation of the LSSF is new to the higher education sector.

Design/methodology/approach – Using the standard DMAIC cycle as the key driver in the implementation process, most in-depth Lean Six Sigma (LSS) case studies have focussed on manufacturing and engineering-based problems and solutions. This case study offers a detailed analysis of the design and implementation of an integrated LSSF within higher education and focusses primarily on the curriculum design and delivery of a new undergraduate engineering programme in a subject university. As such, this offers a unique perspective of LSS implementation in Higher Education Institutions (HEIs) which drives systems improvements in to the heart of the teaching and learning process.

Findings – The design, development and subsequent application of the LSSF enabled the curriculum development team to comprehensively apply LSS in to a subject institution. The Shainin Key Variables Search Technique (KVST) more specifically enabled the team to prioritise the key variables by way of order of importance and, this allowed the team to apply the most appropriate tools and techniques at the key points within the LSSF in order to obtain maximum performance.

Research limitations/implications – Whilst this work provides key information on how LSS initiatives are implemented across different institution types, the work has only focussed at a very small sample of HEIs and the case study only being applied to one institution. The work will need to be extended much more widely to incorporate a larger set of HEIs (both research and teaching focussed) in order to provide a more complete map of LSS development in HEIs.

Practical implications – The aim of the paper is to provide LSS project leaders in HEIs with a coherent and balanced LSSF in an attempt to assist them in implementing comprehensive LSS programmes thus maximising the improvements in efficiency and operational performance of departments within HEIs.

Originality/value – This paper is the first of its kind to study the application of Shainin's KVST in the implementation of LSS programmes in HEIs. The key features highlighted in this work raise important issues regarding the need and importance of developing a balanced LSSF for HEI project implementation.

Keywords Lean Six Sigma, Lean, Higher education, Shainin KVST

Paper type Case study

1. Introduction

The application and implementation of Lean programmes within higher education has been the focus of much academic debate and development over the years. Following its original application the manufacturing industry Lean has spread rapidly in to the service sector and now in to higher education. Exponents of Lean implementation in Higher Education Institutions (HEIs) (Balzer *et al.*, 2015; Emiliani, 2004, 2005; Radnor and Bucci, 2011) have identified the positive impact that its application has had on the sector.

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As a result of a number of successful applications, Lean has taken a hold in the psyche of many HEI managers thus making it an increasingly utilised methodology.

Six Sigma can claim more modest utilisation and usage within the HE sector. Early academic development from researchers such as Holmes *et al.* (2005) and Mazumder (2014) outline the application of Six Sigma in HEIs. Following the standard DMAIC process, the academic literature reports modest results from its application. Also, the number of Six Sigma implementations can be seen as being significantly lower than those of Lean (Thomas *et al.*, 2015). It could be argued that in a sector which is only just starting on its journey around the formalised application of business improvement methodologies that the greater predominance of Lean implementation over Six Sigma implementation is to be expected and that the outcomes obtained from successful implementation of Lean may be more tangible and easily recognisable than those obtained from the more statistically-oriented Six Sigma approach.

However, where the application of Six Sigma takes hold within HEIs is in its integration within the Lean Six Sigma (LSS) framework. LSS in general has quickly gained favour amongst practitioners and academics and has now become a widely-utilised business improvement methodology which has been successfully applied in a wide range of businesses. LSS aims to drive business process improvements through adopting the key features of both Lean and Six Sigma and combining these features in to an integrated approach towards business performance enhancement (Thomas *et al.*, 2015). In so doing, companies focus on systematically creating value and reducing and removing waste (the lean element of the approach) whilst employing Six Sigma to focus on and to eradicate the Critical to Quality issues that affect an organisation (Zhang *et al.*, 2015; Drohomeretski *et al.*, 2013). In applying this combined approach, LSS aims to achieve more efficient flow of services whilst systematically eradicating any issues which could adversely affect the quality and performance of the business process. Earlier pioneers of LSS such as George (2003) proposed combining Six Sigma with that of Lean in order to achieve performance improvements that could be gained quicker and more effectively than applying Lean and Six Sigma as distinctly separate strategies. His work proposes the utilisation of the Six Sigma DMAIC cycle as the central driver of LSS where appropriate lean and Six Sigma tools are applied to each stage of the DMAIC cycle.

This paper provides a unique contribution towards extending the body of LSS implementation in to HEIs through developing an integrated and balanced LSS HEI implementation framework. Through a systematic approach to analysing literature around the implementation of Lean, Six Sigma and LSS in to HEIs, an understanding is obtained as to the current development of LSS in the sector. The work then goes on to show the findings of a primary data analysis of process improvement applications in eight HEIs (lean and LSS applications). From the data analysis, an outline LSS HEI framework is proposed for implementation. The framework is subsequently implemented in a selected HEI with the resulting outputs analysed and the framework subsequently fine-tuned and adjusted following implementation and analysis. The new implementation framework proposed is one which enables HEIs to systematically develop and implement LSS in a coherent and balanced way. The emerging framework is the first of its kind and one which targets specifically the management of course and programme design in HEIs.

2. A literature review and analysis of LSS in HE

The uptake of the LSS methodology is still very much in its infancy within HE institutions, current academic work around LSS HE involves understanding the basis in which LSS is to be applied and, characterising the nature of the LSS journey that the HEIs will embark upon. This involves highlighting the typical barriers and inhibitors to the successful application of the LSS methodology in HEIs (Antony, 2014; Svensson *et al.*, 2015). However, at present, little academic work has been undertaken in the systematic and robust application of the

LSS methodology to HEIs and few implementation case studies exist in this area. Table I shows a systematic review of the key application/implementation literature in the area of Lean, Six Sigma and LSS. The table highlights the focus of the work and the areas within the university environment where the application of the business improvement methodology has been undertaken. The work neatly highlights the nature of the implementation programmes. It shows that Lean implementation has primarily focussed on support departments such as libraries, finance departments and student support services have been tackled through the methodology. Emiliani (2005) outlines the approach to employing Kaizen techniques on course development within a US university. Likewise, Emiliani (2004) outlines the application of Lean in improving the MBA programme in a HEI in the USA. However, it is only recently that Lean is being applied to reducing waste in the Teaching and Learning functions within HEIs. In summary, much of the Lean implementation work shows significant academic development as well as strong improvements in performance. The work also highlights the predominant focus on support services as the key targets for Lean implementation. The focus upon the application of Lean to non-teaching activities suggests that improvement teams may see such functional areas as areas of high waste and cost; and therefore, further highlights that the reason for selecting such projects is on the basis of cost reduction rather than on value maximisation and waste reduction from the customer's perspective.

Six Sigma implementation in HEIs on the other hand provides a contrasting view in many cases to that of Lean implementation. Through the rigorous analysis of business process data and a clear and well-executed application of statistical tools, Six Sigma implementation focusses upon the systematic improvement of key problem areas within HEIs. However, little academic work exists around the actual implementation of the methodology in a HE environment. Much of the academic literature around Six Sigma implementation is based around understanding the nature of Six Sigma and proposing methods on how to apply the methodology in to actual situations. Holmes *et al.* (2005) and Bandyopadhyay (2007) for instance show how Six Sigma could be used in the application of variation reduction and process improvement (identifying the typical KPIs which could be used, and identifying the areas which could be focussed upon at each of the DMAIC stages). However, little information around the detailed application of Six Sigma in HEIs exists.

LSS however, whilst still in its relative infancy, shows a strong and emerging area of academic development. Similar in nature to the academic development of Lean, most of the work in this area currently focusses on the preparedness and readiness of HEIs to apply and develop LSS as a new methodology for their institutions (Antony *et al.*, 2014). Further academic development around how LSS is able to be oriented to fit within the HEI system has been carried out by researchers such as Hess and Benjamin (2015) and Antony *et al.* (2012).

When analysing the academic development of LSS in HEIs, a number of key issues emerge, these are:

(1) The LSS tools and techniques adopted are primarily Lean oriented (Value Stream Mapping, Cause and Effect Analysis, 5S, etc.) thus suggesting that the application of Six Sigma tools and techniques within an LSS model are not routinely used.

(2) HEI LSS implementation uses the standard DMAIC methodology but shows little application of statistical analysis as a means of driving project implementation. The literature suggests that DMAIC is a convenient framework whereas the tools applied are in essence Lean tools.

(3) There is little evidence to suggest that HEI-based Lean or LSS projects focus upon the process of defining customer value and the translation of customer requirements to identifying key strategic issues around the teaching and learning elements of the HE system.

Table I.
Academic literature analysis of lean, SS and LSS in HE

Author	Methodology employed	Approach taken	Findings of the study	Lean, Six Sigma or LSS techniques applied
Antony *et al.* (2012)	Lean Six Sigma	The paper discusses whether LSS can be a useful and systematic approach to tackle operational and strategic issues HEIs. The authors use secondary data from literature to justify the need for this approach and the benefits of adopting this business process improvement strategy within HEIs	The paper presents the challenges and barriers to be encountered during the introduction of LSS in the higher education sector, most useful tools and techniques for process improvement problems, success factors which are essential for the implementation and sustainability of LSS	Barriers and limitations
Antony (2014)	Lean Six Sigma	A key study in to identifying the readiness factors required for HEIs to adopt in order to ensure smooth implementation of LSS. Secondary literature based, it identifies the key issues around preparedness and readiness	Secondary data around readiness factors and identification of key RFs for the smooth implementation of LSS. Key RFs are: leadership and vision, management commitment and resources, linking LSS to strategic aims, customer focus and, selecting correct people,	Identification on readiness factors
Balzer *et al.* (2015)	Lean	Through literature review and personal experiences the authors provide information on organisational change and transformation to implement and sustain Lean initiatives in HEIs	The authors address the importance of Lean techniques for first, assessing and improving institutional readiness; second, enhancing leadership awareness, understanding, and support for Lean implementation; third, strategic planning, leadership, and getting help for LHE; and fourth, facilitating an institution-wide transition to LHE	Literature review outlining general Lean tools and techniques
Bandyopadhyay (2007)	Six Sigma	The paper attempts to develop a Six Sigma model for a HEI in the USA	Focus on waste reduction areas within HEI. Follows DMAIC approach without any application of key Six Sigma statistical issues	DMAIC cycle without specific tools identified
Comm and Mathaisel (2003, 2005)	Lean	Questionnaire to 18 public and private universities in the USA and analysed	Although the universities surveyed implemented Lean often without knowledge that they were implementing "lean" practices, their application has often reduced waste, improved operational efficiency and contributed to sustainability	Identifies the Lean thinking cycle and highlights the issues around leadership and training of staff in the principles of Lean 2003 paper identifies VSM technique and highlights 9 overarching practices (Ops) that should be followed to apply Lean in HEIs

(*continued*)

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Doman (2011)	Lean	This is a first-hand account by the instructor of a small group of undergraduate students in a seminar course working as a team to identify waste and redesign the university's grade change administrative process	Showed how a small group of undergraduate students can quickly learn basic lean principles, tools and practices, and reinforce that learning by applying them in a team effort to significantly improve a university administrative process	VSM techniques employed and teaching of the Lean thinking principles undertaken
Douglas *et al.* (2015)	Lean	Through observation, questionnaire and interview, waste reduction and other Lean systems were identified and validated by the authors	Appropriate Lean solutions to the identified wastes include the use of 5S, point-of-use-storage, process mapping/value stream mapping and level scheduling were identified	5S, point-of-use-storage, process mapping/value stream mapping and level scheduling were identified
Emiliani (2004)	Lean	Case study development of Lean implementation in to a graduate-level business studies course in a US university. Generic lean overview before matching lean theory with HE targets and highlights focus areas for development	Evaluation made of application of Lean tools such as; 5S, continuous improvement, JIT in script marking, etc. Positive improvements seen in student experience and instructor performance	Identified the lean thinking cycle and also applies some of the key lean tools to education examples. Tools identified are: 5S, standard work, visual controls, JIT, load smoothing, respect for people, voice of customer
Emiliani (2006)	Lean	Case study development and focus is on correcting several obvious deficiencies in courses and degree programs to create highly differentiated educational experiences that are more relevant to student's needs and the organisations that employ graduates	Proposes a suite of 11 interconnected improvements (such as; simplify curriculum, improve relevancy and interest in subject, etc.) as well as a fundamental re-structuring of the MBA programme designed to simplify it, provide greater focus, improve relevancy, and impart needed thematic consistency	Identifies 11 deficiencies in education management but does not focus on the application of specific LSS techniques
Hess and Benjamin (2015)	Lean Six Sigma	Identifies through literature analysis the relevant opportunities for the application of LSS within HEIs. The paper also discusses the challenges of LSS implementation in HEIs	Literature review and discussion focus. Identifies the cultural changes necessary to provide an appropriate climate for its long-term success in HEIs	Cultural changes and analysis

(*continued*)

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Hines and Lethbridge (2008)	Lean	Semi-structured interviews with client universities in the USA along with a comprehensive literature review to provide an understanding of various Lean university initiatives	There is much potential to improve customer value and eliminate waste in universities. However, their study outlines that it is increasingly evident that the academic environment is harder to change than many conventional Lean environments. In common with many older universities, the strategic structures are unaccustomed to rapid change	Lean Iceberg Model highlighted and its applicability to Lean university projects is outlined
Holmes *et al.* (2005)	Six Sigma	Literature review of the key aspects of Six Sigma and how the principles can be applied to educational environments	Outlines the DMAIC cycle and identifies the specific tools and techniques that can be used to drive Six Sigma implementation. Secondary data driven	DMAIC cycle without specific tools identified
Isa and Usmen (2015)	Lean Six Sigma	Used VSM and cost analysis to identify VA and NVA activities	Application around employing LSS to facilities management within Universities	VSM techniques
Kanakana *et al.* (2012)	Six Sigma/ Lean Six Sigma	Case study application outlining the LSS process in improving throughput time and variation around throughput time in a HEI in South Africa	Outlined as a LSS project, the work is focussed more on the application of Six Sigma rather than applying any significant Lean techniques. Outlines DMAIC and details the application mechanisms	DMAIC and Lean applied around a hypothetical system
Mazumder (2014)	Six Sigma	Case study and application in US HEI	A case study application of the Six Sigma Methodology applied to US HEI. The author shows how Six Sigma techniques are used in a HE environment	FMEA, C+E and VSM and control charting
Moore and Nash (2004)	Lean	Case study on the University of Oklahoma's university administrative system. Outlines a 4 stage implementation process and describes the development and management of the Lean process	Focus on the administrative area of the university. identifies key Lean tool application around VSM, Kaizen blitz projects with a focus on cost reduction and waste elimination (e.g. reducing cost of paper by moving from paper communication systems to e-mail, etc.)	Application of VSM and 4 step method towards process improvement

(*continued*)

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Ramasubramanian (2012)	Six Sigma	Literature review of the key aspects of Six Sigma and how the principles can be applied to educational environments	Outlines the DMAIC cycle and identifies the specific tools and techniques that can be used to drive Six Sigma implementation. Secondary data driven	DMAIC cycle without specific tools identified
Salewski and Klein (2009)	Lean	A thought piece on describing the implementation of Lean in universities via a 5-point plan. Describes the development and management of the Lean implementation process	A generic focus on the drivers and conditions to develop Lean in universities. Identifies the key issues of communication, top management buy in and roles of champions in the lean delivery system	Identifies a 5 stage implementation process
Svensson *et al.* (2015)	Lean Six Sigma	The paper reviews the initial phase of a wide scale LSS implementation in a Saudi HEI and highlights the future challenges of applying the LSS method in the wider HE industry	The study provides strong evidence of the need to undertake a wide scale training initiative to train and prepare key teams in the application of LSS. The paper shows the impact of such training through the successful achievements in business process improvements in the HEI	Preparedness and training around LSS
Thomas *et al.* (2015)	Lean	A comparator analysis that surveys the approaches and levels of Lean Implementation activity taken between FEIs and HEIs	The study found that although FEIs had much more experience in the design, development and implementation of Lean initiatives, the organisational infrastructure and dynamics towards driving Lean in FEIs was less well embedded in to the culture of the respective institutions. It was seen that whilst HEIs were generally slower in getting off the mark, there seemed to be more enthusiasm and willingness to drive such initiatives forward and in a more systematic and holistic manner	Identifies some use of Drum Buffer Rope Techniques and Theory of Constraints approaches. VSM techniques also employed in two HEIs
Tischler (2006)	Lean	Provides case studies/exemplars of Lean implementation projects in the student applications system	Focus on the student applications area. Identifies key Lean tool application primarily around VSM. Shows the integration of IT systems development to achieve savings in cost and reduction in NVA activities	High level VSM approach with a 5 step improvement method highlighted

(4) Following on from the previous issue, whilst there is a strong and emerging field of academic literature in the area of establishing what LSS means to the HE sector and, how LSS could be implemented, there is little by way of strong evidence of the detailed application and analysis of LSS implementation within HEIs (especially in the teaching and learning areas of HEIs).

3. Methodology

In order to establish a wider context for the development of a new and more integrated LSS HEI implementation framework, it is important to obtain primary information directly from HEIs which are involved in business improvement initiatives (whether they be Lean, Six Sigma or LSS). The aim of the initial, survey phase was to draw from the practitioner base the key strategies, systems, tools and techniques that were being employed in HEIs. The second phase of the research design was to develop and test an implementation framework that addressed existing deficiencies established in the literature review and in the survey phase.

3.1 Primary data survey

Eight HEIs from across the UK agreed to take part in the short survey project to highlight the following issues:

(1) To identify the business improvement strategies employed by the HEIs and from this to identify the key tools and techniques employed by each HEI.

(2) To identify the key barriers and reasons why HEIs favoured one specific business improvement approach over another. More specifically, to identify why HEIs in the main have resisted the implementation of LSS.

The investigation in to each HEI took one day to complete and the person identified to undertake the investigation was the business improvement manager (i.e. Business Improvement Leader, Lean Champion and/or LSS Champion). Observational data and verbal responses to the semi-structured interview questions were collected from each leader. The questionnaire collected information and feedback in the following areas:

- Strategy – purpose, drivers and objectives of improvement programmes (IPs), main or primary IP employed.
- IP – type employed, its location within institution, process being tackled, effectiveness of the IP, tools employed.
- Barriers and limitations – barriers that prevent the use of LSS. Barriers that limit the full use of LSS (in HEIs purporting to use LSS).

3.2 Development and testing of implementation framework

This paper will be one of the first to show a full implementation of the LSS methodology in a HEI. Furthermore, the case study shows its application in a Teaching and Learning environment and therefore offers a contrast to the majority of Lean application projects. This paper will detail the development of a Lean Six Sigma Framework (LSSF) which enables the full development of the Lean thinking framework to operate within the proposed LSSF. This will be the first time that this integrated LSSF has been applied in a HEI and the paper will attempt to highlight the early stage benefits obtained by the institution through its implementation. The LSSF has been developed and successfully applied previously in the aerospace industry (Thomas *et al.*, 2016). The aim of this paper is to also propose a methodological contribution in assessing how effective is the application of the LSSF in the HE sector.

The case study follows the implementation of the LSSF in to a standard UK Teaching-led University and focusses upon the new product development process and how the combined approach of both Lean and Six Sigma worked to systematically reduce time to market of the new course whilst using Six Sigma's focus on quality improvement to ensure that the product not only exceeded current and future student needs but enabled its robust and repeatable application in to future product development programmes. Therefore, three research questions are proposed in this phase of the work are:

RQ1. How applicable is the implementation of the LSSF approach in the HE sector?

RQ2. To what extent does the implementation of the LSSF assist in the improvement of the HEIs product development process?

RQ3. What specific LSS tools and techniques are best applied to each stage of the LSS project?

4. Survey results

Table II shows each of the HEIs and further outlines the main focus of business improvement. The study was also able to identify the key focus of their improvement strategy as well as outlining the key issues around the barriers and limitations of LSS implementation in their respective institutions. Observations along with interviews and a semi-structured questionnaire allowed the authors to triangulate the qualitative data. A summary of the key findings from the study were:

(1) Little systematic widespread use of LSS was seen. In virtually all cases it was the Lean methodology that was seen as the strategy of choice in the HEIs. Even those whom purport to use the LSS approach used DMAIC as the framework in which to apply Lean tools and techniques. This suggested that HEIs used Lean and LSS as a tool-driven concept rather than a philosophical approach; with little attention being paid to the concept of Lean thinking and variation reduction. Rather, HEIs used the work to tackle single problems and provide solutions to given constraints in the system. Since the teams largely knew the causes of the issues then the application of Six Sigma tools became largely redundant (Hoerl, 2004).

(2) There was very little evidence of any application of advanced Lean/LSS tools being used. Most tools employed were simplistic and standardised in nature (VSM, C+E, Pareto, SIPOC, etc.). Whilst these seemed to work correctly and effectively, the study suggested that the LSS and Lean projects were somewhat simplistic in nature and as a result yielded modest improvements in system performance. This could be attributed to the somewhat early stage development of business improvement in HEIs where further in-depth studies will push the teams towards more advanced tools and techniques.

(3) Of the two institutions who claim to employ the LSS approach, neither institution had attempted to fully integrate both Lean and Six Sigma in to a coherent system of operation, preferring to use mainly the Lean tools whilst backing up specific areas through the application of some simplistic Six Sigma tools. Therefore, no formal approach to a balanced and fully integrated LSS approach was undertaken.

(4) Of the institutions who employed Lean, the overwhelming response as to why LSS had not been considered for adoption was due to the institutions failing to see the benefits of employing the Six Sigma element of the method. Six Sigma was seen as being too "statistically heavy" and required significant investment in statistical training to be of any use. A number of the HEIs had considered using the DMAIC

Table II.
Outputs from primary data phase

Institution	Primary improvement programme	Focus of improvement programme		Tools employed and strategies used	Barriers and limitations to LSS
A	Lean	Recruitment department	Recruitment process	VSM, 5S	New to Lean and could not contemplate taking on the complexities of LSS. Seen as much more scientific where Lean is more management oriented and simpler to implement and monitor
B	Lean	Finance department	Order processing system	CSVSM, FSVSM	Did not see how LSS could fit in to existing systems being developed. Seen as something that could integrate in to Lean but HEI felt it was not mature enough in its Lean implementation cycle to consider LSS
C	Lean	Library and LRC	System layout based on student use	5S, cost analysis on purchasing, string diagrams, POU stores	Could see the benefits of using statistical monitoring to improve layouts and efficiency but felt that Lean was doing the job at the moment
D	Lean	Engineering workshop	Workshop processes and timetabling flow	5S, VSM, Pareto	Did not see how the Six Sigma elements of LSS could fit or integrate in to the existing Lean programme. Could be too complex and difficult to run when comparing the benefits that could be brought about by LSS
E	Lean Six Sigma	Business school	Recruitment variation and improvement	C+E analysis, QFD, SIPOC, capacity planning	Primarily focussed upon Lean approach and using very simple SS techniques to assist in improving recruitment process which is expensive and yields lower than expected results to department. Have not thought of using LSS for teaching delivery improvement but envisage it would be very difficult to implement in this setting
F	Lean Six Sigma	Engineering department	Resource balancing and reduction in hourly paid staff. Variation reduction around resource allocation	Workload levelling and asset balancing, Pareto, VSM	Although the team identified they employed LSS techniques, it was difficult to see what Six Sigma approaches were used. However, the team employed the DMAIC cycle to drive their projects rather than the 5 stage Lean cycle. No integration of Lean and DMAIC cycles seen

structure and saw this as a major benefit of Six Sigma implementation. However, none of these institutions employed a correctly-developed Lean system and whilst they were aware of the five stage Lean cycle, little evidence existed that the institutions followed this approach with any rigour.

In summary, of the eight institutions surveyed, both the Lean cycle and the DMAIC cycles were employed with varying levels of rigour. A clear misconception exists around the implementation of Six Sigma tools and this in turn prevents the HEIs from applying such tools and techniques in their respective institutions. This further leads to simplistic Lean and LSS projects being undertaken which yield limited and modest improvements. As highlighted in the literature review, the HEIs surveyed also mainly applied the business improvement strategies around ancillary and support services and did not focus upon the main value added business process. It was also observed that none of the institutions comprehensively focussed on understanding the process of translating the voice of the customer (VoC) requirements to identify the correct value streams from which LSS projects could be developed for maximum impact.

5. The HEI

The subject HEI is a standard post-1992 academic institution in the UK with full degree awarding powers. The HEI is identified as institution "A" from the survey data collected in Table II and so had an elementary understanding of the deployment of Lean in mostly support functions. It had never previously considered the application of Lean or LSS in the development and improvement of teaching programmes prior to this study.

Apart from its full-time undergraduate programme of courses, the university provides a strong portfolio of part-time undergraduate programmes aimed at the lifelong development of industry-based staff. The department covered in this case study is the engineering department and has for years successfully provided day/evening provision of its engineering programmes allowing industry-based engineers and managers to obtain full BSc degrees in Mechanical Engineering from the institution.

Traditionally, the staff within the department see the part-time provision as relatively stable with student numbers not being adversely affected by significant changes in political policy and industrial/economic issues. This is down to the consistent demand from either industry in order to either develop staff within company or, the individual student requiring technical updating and development or for individuals aiming at developing their own skills and knowledge in order to remain competitive in the job market.

However, over the past four years the department has been concerned that the part-time provision has seen a steady decline it its student base. Whilst full-time student numbers remain relatively static, part-time numbers have seen an average drop of 12 per cent year on year over this period of time. Student numbers for the BSc degree in Mechanical Engineering were riding high at 45 per annum in 2010/2011 academic year but had dropped to just over half by the 2013/2014 academic year to 23 students. Despite attempts to address the issues around lack of industry support and interest (industry liaison groups, student focus groups, etc.), little has been effective in stemming the loss of students from the programme. Since the 2014/2015 academic year would see the need to review and revalidate provision within the department, the school management team decided to undertake a root and branch analysis of the provision in 2013/2014 and take the remaining 12 months to undertake a full LSS implementation programme on the BSc Mechanical Engineering Course. The decision to implement LSS was not just based on the need to improve the course through updating its delivery mechanism and student recruitment systems, the management team were keen to embed Lean practices and systems within the department and to use the BSc programme as a pilot study so that roll out of provision could be initiated if the project was seen as a success.

6. The development of the LSSF

The evidence base provided within this paper from analysis of existing literature and from the primary survey work lead the authors to argue that much of the LSS implementation is highly Lean oriented and that simplistic Lean tools and systems are applied within the standard DMAIC structure. The authors suggest this naturally moves the LSS teams towards the application of a narrow and focussed set of Lean tools and techniques. In so doing, the practitioners do not fully extract the full benefits of LSS via this approach and thus limit the project's effectiveness.

To provide a focal point to the development of a HEI LSSF, the authors employed an inductive approach to framework development and used the LSS model developed by Thomas *et al.* (2016) on which to create the primary foundations of this framework. This LSSF underwent a series of major developments in an attempt to improve its effectiveness and suitability to HEI implementation. Adjustments to the framework included; redesigning the framework to change the points in which the various tools are used. This includes moving the experimental design stage much earlier in the framework so that improvement could be realised much quicker and, providing more focus to the VoC and value analysis stages. Table VII shows the LSSF that was adopted in this study. The LSSF attempts to create a more balanced approach to the simultaneous application of both Lean and Six Sigma in that the DMAIC cycle is implemented at each point in the Lean thinking cycle and proposes the simultaneous implementation of both Lean and Six Sigma in a correctly balanced LSS format. The horizontal axis of the LSSF shows the key elements of the Lean cycle whilst the vertical axis provides the key elements of the DMAIC Six Sigma Cycle. This paper will now focus upon the implementation of this new LSSF and whilst it will highlight the key tools and techniques that were employed, the case study primarily focusses upon stage 1 of the lean cycle and shows how the DMAIC cycle is followed at this particular stage.

7. The LSSF and its implementation

Stage 0 was the starting point of the implementation stage and consisted of a series of awareness-raising sessions in which the implementation process was outlined and where all staff were given the opportunity to contribute to the implementation process and to jointly discuss the direction of travel and, most significantly, to prepare themselves for LSS implementation (Kumar *et al.*, 2011; Kumar and Antony, 2010; Spina *et al.*, 1996). Additional and more focussed training sessions were introduced for staff in order to develop expertise in LSS implementation. Also, the project team delivered practitioner level training to academic staff who would need to carry out much of the developmental tasks. Most importantly, the school management were given awareness sessions and an end of stage 0 meeting clarified the roles and responsibilities of the staff and outlined the timescales and project plans for the implementation of the LSSF. Also, the staff agreed on the key performance measures to be used to measure success of the LSSF. The team considered a wide range of key performance indicators (KPIs) including; employability, progression of student groups but it was decided to focus clearly upon three main KPIs, namely student; Recruitment, retention and results as these were seen as three areas where data could be rapidly collected following LSSF implementation and which directly affected the sustainability of the course.

Early stage work in identifying the typical tools and techniques to be employed in the project was also undertaken at this point. The project team therefore mapped the tools and methods required for each stage of the LSS cycle. The key issue here was to minimise the over-use of tools and to focus upon a core set of key tools for implementation. These were: VSM, Shainin's Key Variables Search Technique (KVST) (Shainin and Shainin, 1988). In order to keep the detail and length of this paper to within acceptable publishing guidelines, this paper will outline the key stages of the LSSF. This will allow for the functioning of the LSSF to be explained and will allow for the use of the key creative tools to be explored.

7.1 Stage 1 implementation

7.1.1 Define. Three workshop sessions were run with four different groups. These groups were: Group 1, full-time existing students; Group 2, part-time students; Group 3, employers from local industry; Group 4, staff members delivering on the programme. Each session was run for two hours each and the aim was to elicit from the groups the main issues surrounding the existing operation of the course and, what additional elements and features that needed to be added to the course in order to improve the programme. Table III shows the primary data response and the key variables highlighted by each of the groups. To focus on the key variables for the study, a clustering analysis was undertaken to categorise the feedback and then a focus group held with the teams in order to gain consensus on identifying a number of possible solutions to remedying the problems faced by the course team. These solutions (variables) were also ranked in order of their importance to the respective teams.

7.1.2 Measure. Table IV shows the clustering and the potential solutions to the issues raised. The table is a simplistic form of the work traditionally undertaken in quality function deployment analysis. Here, the academic team alongside the authors worked to translate the customer "wants" to potential solutions (Hows). It will be these solutions which will become the variables for the study that will then be tested through the KVST to see if the ranked features are important and require further analysis.

7.1.3 Analyse – application of the Shainin KVST. Up to this point, the study has only considered the individual variables which the respondents have considered important to future course development. However, it is important to consider whether these variables remain important when combined together as a series of solutions. In order to accurately identify the key variables that affect course performance, it was decided to employ Shainin's KVST. The KVST enables the management team to robustly identify the key variables in order of importance. The KVST uses a full factorial experimental approach therefore, the reduction of the variables to a vital few is critical before KVST can be applied (Prashar, 2016).

The KVST was then employed to assist the team in identifying the key variables which were important to each stakeholder group within the study. Table V shows the KVST study for the full-time student group. For a full explanation on how the KVST technique is undertaken, the reader is guided to the work of Antony (1999). An initial set of 12 variables were identified. However, after further analysis, variables 12 and 5 were removed since they had little or no impact on the study and, were preventing a suitable DM:Rbar ratio from being achieved (this is the ratio between median and the mean of the range values of the responses. This ratio must be a minimum of 1.25:1 and if so, indicates that the variables selected have the potential to influence the experiment) so that the study could progress (these variables are shown as being marked out in Table V). Removing the variables from the system was safe since the ratings allocated by the groups at both high and low levels were very low and, variation between the high and low values was also seen to be very low thus suggesting the variables had little effect on the experimentation.

KVST is particularly useful in that only one variable is changed at each experimental point thus making it significantly easier for the student group to provide a meaningful response at each experimental point. It was thought that introducing changes to multiple variables simultaneously (as with Taguchi or other DOE approaches) would cause too many difficulties for the respondents to be able to accurately assess any new conditions. Respondents were asked to mark on a Likert scale of 1-10. Each respondent was asked to respond to each question without consultation with other members in the group. In order to reduce bias, the experimentation was undertaken in completely random manner (values shown in the spreadsheet in Table V have been collated for easier analysis). Table V shows the development of the KVST. The key variables that are of interest to the experiment are listed in column 2 and coded in column 1. The participant scores for each experimental point

Table III. Primary data response from survey

Group 1 (FT students) $n=16$	Group 2 (PT students) $n=18$	Group 3 (employers) $n=12$	Group 4 (staff members) $n=6$
More opportunities for industrial placements	Assessments to be better aligned to industrial problems	Teaching to be focussed on industry specific needs. New modules around management needed	Time to bring validation through system is lengthy and conflicts with teaching loads. Needs to be a way to speed things up
Wider range of staff delivering on programme	Timetabling all work on single day is preferred	Blended learning with high online content to limit time away from work	Investment in upskilling staff needed. Work falls to small number of staff
Better library facilities	Blended delivery with larger element of online work preferred	Graduates to be better equipped with leadership and management skills	
Improved course materials with latest ideas and trends	Lectures to be more focussed upon industry problems	Reduce length of course to ensure students complete in shortest possible time	
Better access to VLE	Better access to VLE	FT Graduates to be much more work ready	
Improved delivery of courses by inspiring lecturers	Cut course length down to 3 years	Graduates to have the latest state of the art thinking in engineering and management theory	
Smaller class sizes	Professional body accreditation sought		
More seminars and less direct teaching	More work around solving industrial and management problems		
More problem-based learning			
Timetabling to be better scheduled throughout the week.			
Session length of 50 minutes is preferred			
Blended delivery with larger element of taught/practical sessions preferred			
Assignment feedback turn-round slow to come back and insufficient feedback given			
Professional accreditation is good but not essential			
More experience of real world environments			

Customer (Wants)	Variables (Hows)
Employability: work placements, problem-based learning, experiential learning	V1 increase work placements from 2 weeks to 3 months V2 make course PBL oriented V3 introduce industry mentors
Quality of Learning: better course materials, VLE better equipped and used, inspirational teaching, seminar delivery	V4 all course materials on to VLE V5 tutoring and seminars only V6 delivery of material via VLE only
Structure of programme: better timetabling, shorter period in which to graduate, greater use of VLE systems	V7 flexible timetabling V8 module credits accrued through project completion
Skills and knowledge: leadership and management skills, soft skills development, state of the art knowledge base	V9 integrate L+M skills in to projects V10 latest research ideas delivered
Curriculum: professional body accreditation, new modules in L+M	V11 Professional Body accreditation
QA process: reducing validation time, staff upskilling	V12 reduce validation from 30 to 10 weeks

Table IV. Simplified QFD with variables identified

are shown in column 4 for each variable setting shown on the right hand side of the table. Statistical significant variables are identified where their output value falls outside the control limits.

The outputs from the study with the full-time student group threw up a number of interesting issues. A central issue which emerged from the VoC stage was that FT student's focus was primarily on employability and the need to obtain good jobs and prospects following the attainment of their qualification. The KVST study, however, identified variables 3, 5, 7, 8, 10 as important whereas variable 1 which the experimenters thought would be significant in obtaining employment (an increased period of work experience) was not seen as important to the FT student group. Likewise, variables 7 and 8 were seen as important at both high and low levels (timetabling and project work respectively) which suggests that FT students were considering the structure of the course as more important than what the course could do for their careers.

KVST studies on the part-time student group showed that variables 2, 5, 6, 7, 8 and 10 were important. Variables 1 and 3 were not seen as important. This was expected since this student group were employed students. The employer group was asked to respond on the design and structure of the full-time course as it was important to extract the information required to align the FT course to the employment opportunities offered by the companies. The KVST identified variables 1, 2, 3, 9 and 10 as being important. Table VI shows the comparison of the variables for each stakeholder group marked with X on the table.

The results of the KVST provided important information on the major variables which were important to study in the remaining LSS project. The work also enabled the course team to consider a number of strategic issues around the course design and development. The key issue was seen around the mis-match between what employers wanted from the course in order to make the student groups employable and what the students saw as being important to them. Therefore, issues around increasing work experience was seen as critical to employers but not to FT students. Variable 11 was not seen important to any group. This is of particular interest since the involvement of professional bodies in the development and validation of engineering programmes has been key in the past. However, further analysis and discussion of this issue with the stakeholder groups showed that due to the fact that the course did not allow students to progress to Chartered Status (as it had not followed the recognised validation route) then the question was not seen as particularly relevant. Also, staff focus was based around reducing time to validation. Whilst seen as a perfectly acceptable objective, it was not valued by any client group studied. The analysis suggested

Table V. Key variables search analysis

	Variables		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	Mean High Low Xbar (H)	Xbar (L)	Median High Low x MH	x ML
V1	Work Placements of 3 months per year	MH	7.5	7	7.5	7	7	8	6.5	7	7.5	6.5	7	8	7.5	8	7	8	9.2		7.3	
V1	Work Placements of 2 weeks per year	ML	3	4	3	3	4	3	3.5	5	4	4.5	3	4.5	4	5	4.5	4.5		3.8		4.0
V2	Make course PBL oriented on all modules	MH	6	7	8	6.5	6	8	6	8	6	6.5	6	8	7	6.5	7	7	8.8		6.8	
V2	No PBL on modules	ML	5	4	4.5	4	5	4	4	4	5	4	4.5	5	4	4.5	4.5	4		4.2		4.3
V3	Introduce Industry Mentors	MH	8	8	7.5	6	8.5	6	8.5	8.5	8	7	7.5	8.5	8	7	7.5	6	8.7		7.8	
V3	No Industry Mentors	ML	4	3	5	5.5	5	5.5	3	6	4	4.5	3	3.5	5	4.5	4	4.5		4.2		4.5
V4	All course materials on to VLE	MH	4	4	5	4	5	6	5	4	5	6	5	4	5	7	6	5				
V4	Only some course materials on to VLE	ML	5	6	7	6	7	6	7	5	4	4	5	4	4	4	5	4				
V5	Tutoring and seminars only	MH	7	7	8	8	8	7	8	7	8	7	8	7	7.5	7.5	8	8	7.6		7.8	
V5	Formal Lectures mainly	ML	3	4	4	3	4	3	4	4	4	3.5	3	3.5	4	4	3	6		4.2		4.0
V6	Blended learning approach	MH	6	7	6	7	8.5	8.5	7	6.5	6.5	6	7	7.5	7	7.5	7	6.5	6.2		7.0	
V6	Delivery of material via VLE only	ML	4	5	6	6	4	3	4	5	2	5	4	2	4	4	3	3		5		4.0
V7	Flexible timetable	MH	8	7	8	8	7.5	8	7.5	8	7.5	7	8	7	8	7	7	8	7		7.8	
V7	Formalised timetable with set allocations	ML	5	4.5	4.5	5.5	4	5.5	5	5	5	4.5	4.5	5	4.5	4.5	5	4.5		4.1		4.8
V8	Module credits accrued through project completion	MH	7.5	7.5	8	8	6	7	6	9	7	9	9	8	7	8	8	7	7.4		7.8	
V8	Module credits accrued through assessments & exams	ML	3.5	3.5	5	3.5	5	5	5	5	5	4.5	4.5	4	4.5	5	5	4.5		5.2		4.8
V9	Integrate L+M skills in to projects	MH	6	7	7	6.5	6	7	8	6.5	8	7	6.5	8	6.5	8	6	6.5	7		6.8	
V9	Technical Skills content mostly	ML	3.5	4	3.5	4	3	3.5	4	3.5	3.5	3.5	4	3.5	4	4	4	4		5.2		3.8
V10	Research led teaching	MH	7	7	7	7	7	7	8	8	7	7	8	8	8	8	7	8	7.2		7.0	
V10	Traditional text book teaching	ML	4	4	5	5	5	5	6	4	5	4	5	5	4	5	4	4		5.2		5.0
V11	PB accreditation	MH	6.5	7.5	7	7.5	6	6	6.5	7.5	6.5	7.5	7	7.5	7.5	6.5	6.5	6	7,2		6.8	
V11	No PB accreditation	ML	4	3.5	3.5	4	5	4	4	3.5	4	3	3	3	4	3	3	4		3.1		3.8
V12	Reduce Validation to 10 weeks	MH	2	3	2	2	2	3	2	3	4	3	2	3	2	3	2	2				
V12	Maintain Validation at 30 weeks	ML	3	2	3	3	2	3	3	4	3	2	2	2	3	2	2	3				
																			7.68	4.42	7.13	4.13

Variables at High and Low Settings

		V1(H)	V1(L)	V2 (H)	V2 (L)	V3 (H)	V3 (L)	V5 (H)	V5 (L)	V6 (H)	V6 (L)	V7 (H)	V7 (L)	V8 H	V8 L	V9 H	V9 L	V10 H	V10 L	V11 H	V11 L
V1	MH		1	1		1		1		1		1		1		1		1		1	
V1	ML	-1			-1		-1		-1		-1		-1		-1		-1		-1		-1
V2	MH	1			1	1		1		1		1		1		1		1		1	
V2	ML		-1	-1			-1		-1		-1		-1		-1		-1		-1		-1
V3	MH	1		1			1	1		1		1		1		1		1		1	
V3	ML		-1		-1	-1			-1		-1		-1		-1		-1		-1		-1
V4	MH																				
V4	ML																				
V5	MH	1		1		1			-1	1		1		1		1		1		1	
V5	ML		-1		-1		-1	-1			-1		-1		-1		-1		-1		-1
V6	MH	1		1		1		1			1	1		1		1		1		1	
V6	ML		-1		-1		-1		-1	-1			-1		-1		-1		-1		-1
V7	MH	1		1		1		1		1			1	1		1		1		1	
V7	ML		-1		-1		-1		-1		-1	-1			-1		-1		-1		-1
V8	MH	1		1		1		1		1		1			1	1		1		1	
V8	ML		-1		-1		-1		-1		-1		-1	-1			-1		-1		-1
V9	MH	1		1		1		1		1		1		1			1	1		1	
V9	ML		-1		-1		-1		-1		-1		-1		-1	-1			-1		-1
V10	MH	1		1		1		1		1		1		1		1			1	1	
V10	ML		-1		-1		-1		-1		-1		-1		-1		-1	-1			-1
V11	MH	1		1		1		1		1		1		1		1		1			1
V11	ML		-1		-1		-1		-1		-1		-1		-1		-1		-1	-1	
V12	MH																				
V12	ML																				
		6.5	4.0	6.5	3.8	6.0	4.0	7.5	4.0	7.0	3.8	7.5	4.5	7.8	3.0	6.0	3.5	7.5	3.5	7.3	3.5

MH	DM	RH	R Bar	DM : R
7.13	3.00	1.00	1.00	3.00
ML		RL		
4.13		1		

CL =	MH+	2.12	Rbar /	d2		
CL+	7.1	2.12	1	3.53	7.73	7.73
CL-	7.1	2.12	1	3.53	6.52	6.52
CL+	4.1	2.12	1	3.53	4.73	4.73
CL-	4.1	2.12	1	3.53	3.52	3.52

that the staff focussed the LSS project on improving the quality of the teaching and learning programme and the efficiency and effectiveness of delivery rather than the efficiency of the validation process. This enabled the staff to re-focus on what was key to the business process.

7.1.4 Improve – IP. The remaining stages of the LSS implementation are outlined in Table VII. Specific details of the programme for the remaining stages have not been included in order to keep the paper within editorial guidelines. Central to the improvement process was the establishment of the Quality Improvement Group (QIG). The QIGs performed the business process improvement work and introduced the following key stages in to the revalidation phase:

- Introduction of a six-month credit bearing engineering work placement module for FT students thus enabling the students to pick up key work experience without extending the period of the course. Industry mentors (IMs) are assigned to each student not only during the work placement but also during the two years of FT study. PT students are allocated an IM from their workplace and these IMs are encouraged to attend university/student sessions to support their students. Addressing variables 1, 2, 3 and 8.
- Improvement in learning infrastructure with greater budgetary spend on e-books and library facilities. Improvements in the VLE were seen as critical. Addressing variables 5 and 6.
- Improvement in the curriculum provision within the university. Staff teaching on this programme are now engaged in work experience programmes with a range of local engineering companies where they spend 2×2 week technical updating periods in company. Research active staff are able to commute industry updating with their research outputs if applicable. Outputs from the industry and research work must yield at least two significant case studies to be used for delivery in the programme. Addressing variables 5, 8, 9 and 10.
- Engineering professional bodies (EPBs) were asked to sit on the university/employer committee to ensure that the curriculum maintained its appeal and professional engineering relevance. This stage was particularly important in ensuring that the leadership and management module was developed. This module was co-designed with the EPB.

8. Evaluation and conclusions

This paper has shown how the application of the LSSF and in particular, the Shainin KVST can be used to identify the variables that are considered important for the redesign of an academic programme. The LSSF relies heavily on a robust VoC phase which should be undertaken with the widest possible range of stakeholders feeding in to the KVST early in the IP. The VoC phase should be undertaken with care with all variables highlighted and considered carefully before going in to the experimental stage.

Stakeholder group	Variables identified as important									
	V1	V2	V3	V5	V6	V7	V8	V9	V10	V11
FT students			X	X		X	X		X	
PT students		X		X	X	X	X		X	
Employers	X	X	X					X	X	

Table VI. Comparison of key variables of study

Table VII.
The proposed Lean Six Sigma programme

			Lean cycle			
	(0) Train and prepare	(1) Specify value	(2) Synchronise internal value stream	(3) Create flow	(4) Pull on demand	(5) Create perfection
Six Sigma cycle						
Define	Institute departmental wide training in LSS ensuring full preparation in both tools, techniques and management development of LSS leaders	Workshop held with existing students and employers to identify the key value adding issues around the course	Key variables identified from stage 1	Identify conflicting processes causing bottlenecks	Define client expectations around delivery method. Determine volume of students	Identify the areas causing variation from client value perspectives
Measure	Set goals and expectations and establish roles and duties for staff	Competitor performance analysis undertaken (recruitment figures, results profiles, product range, employability profiles, etc.). QFD analysis performed to identify Wants and Hows.\	Set up Quality Improvement Group (QIG) and focus on the design of the value stream and implementation plan	Measure conflicts to see if the issues adversely affect the improvements and undertake action planning	Measure existing teaching delivery capabilities and analyse against client requirements	Measure existing levels of variation through constantly measuring against student focus groups
Analyse	Routinely monitor key business parameters in order to identify early issues which can be worked upon at stage 1 project start	Using Shainin's KVST to identify the key variables that impact on providing an improved course programme	Develop strategies towards implementing solutions	Drive the implementation of the course development programme flow through the system	Identify the features capable of rapid delivery of course. Identify all constraints affecting delivery capabilities	Identify the delivery and client recruitment issues that affect variation. Pinpoint causes and set up improvement teams
Improve		Implementation group set up to consider the key customer variables and to build an effective new BSc degree programme	QIG to implement the recommended improvements (shown in conclusions section)	Identify and remove bottlenecks from system as implementation is undertaken	Establish and embed new technology enhanced learning systems to ensure 24/7 delivery of programme and asynchronous delivery	Establish improvement blitz teams to systematically improve course delivery and manage client expectation
Control		Lock in new course features with validation documentation. QA to update quality procedures and validation protocols	Lock in process optima through new VSM as implementation progresses	Determine new flow system and ensure adherence to new flow paths	Manage new order and embed practices to ensure consistent delivery to standard	Set new process specifications and manage the new process order

Therefore, since this paper applies the LSSF to a single project, only general conclusions can be drawn from the application of this framework at this stage. Therefore, the authors aim to expand the study by applying the LSSF in to similar programme redesign projects as well as more generally across other HEIs to fully test the application of the LSSF to see if the approach can be applied in a range different environments.

The initial VoC stage involved the identification of the key variables considered important by students, employers and staff. The Shainin KVST approach was then adopted to identify which of these key variables were important. The design and development of the LSSF was then key to creating a working environment around which the curriculum improvement work could be enacted. In answering the three key objectives, the following conclusions can be made:

(1) How applicable is the implementation of the LSSF approach in the HE sector?

The LSSF and the application of the KVST shows that LSS can be effectively delivered in to HEIs in a critical area such as curriculum development and enhancement. Whilst it can be argued that the LSSF is more lengthy, requiring the LSS teams to go through more stages, it has been effective in introducing more Six Sigma techniques and processes that had been traditionally applied in previous HEI improvement projects. The KVST also assisted in removing the fear of complex statistics and was a technique that the QIG members had highlighted as being particularly effective without being hugely burdensome:

(2) To what extent does the implementation of the LSSF assist in the improvement of the HEIs product development process?

The LSSF was seen as the main change agent for the project. Feedback from the management team showed that the improvements adopted by the course team would not have happened unless the LSSF system had been adopted. Furthermore, staff motivation was seen as having improved as a result of having a greater say in the development of the curriculum and, student satisfaction had improved as their voice had been seriously considered and their suggestions taken on board. For employers, the exercise enabled them to move closer to the curriculum and course offering at the university and to some, this was the first time that they had experienced curriculum design and development:

(3) What specific LSS tools and techniques are best applied to each stage of the LSS project?

The balanced approach towards multiple stakeholder analysis was seen as being particularly effective and that the KVST was very useful in developing a robust statistical platform for basing improvement actions. It was observed that staff were less inclined to argue with the student feedback once it has been captured for the KVS process so the movement on to curriculum changes and process improvement was swift.

Whilst it is too early in the course delivery process to clearly see if the curriculum design changes have taken effect, the school's management team found the exercise to be key in initiating and driving change in to the curriculum. Roll out of the LSS programme is being considered for further curriculum design and redesign projects within the university.

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