

A dynamic approach to teaching LSS at Universities

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ABSTRACT

Alongside the European Students of Industrial Engineering and Management (ESTIEM) a team of students from the University of Minho, in cooperation with a corporate partner, developed a free and scalable Lean Six Sigma (LSS) Green-Belt level course for Engineering students.

Purpose: The authors aim to depict how free access to LSS Green-Belt knowledge before graduation can positively impact both engineering education and the students when in real-life projects. The purpose is not to build on existing literature, but to provide a practical teaching structure.

Methodology: The authors chose to follow the hypothetico-deductive method which consists of formulating hypotheses and comparing them with real-life brought up from their personal experiences while teaching the course.

Findings: This case study found a positive impact on both the students responsible for facilitating the training sessions, as well as the ones receiving practical and theoretical knowledge. With more than 60 course graduates, this model is generating positive results in growing awareness for LSS methods.

Practical implications: This paper describes a practical application of a novel approach to teaching LSS in Universities along the obstacles surpassed to design it, blending it in the course curricula. It aims to foster similar implementations in other institutions.

Originality: A teaching system built with students for students is scalable, low-cost, and highly engaging. Its deployment not only shows how it is possible to advance education by blending an existing LSS course structure but also how students can greatly benefit from a deeper LSS knowledge before their graduation.

Keywords: LSS, Industrial Engineering, and Management, Engineering Curricula, Teaching methodology

Paper type Case Study

INTRODUCTION

The world is changing every single day. The economy is changing, technology is evolving and most importantly the authors, as human beings, are changing. This means our behavior, our beliefs, and our necessities are changing. So, how can the authors adapt and prosper in such uncertainty? Considering what Universities have been doing to prepare the future workforce and leaders of the incumbent industries and the new sectors yet to arise, engineering graduates still seem to be closing themselves down to the same old classic tools from the mass production days of Ford - learning how to answer, but not how to question the context around them. This is the reason it was created the first free certified LSS Green Belt course at the University of Minho, designed by students for students with the future in mind.

This paper was prepared by the students who participated in the structuring of this course, with the involvement of ESTIEM (European Students of Industrial Engineering and Management) as an educational partner - giving support and feedback on our first trial edition at the University of Minho; and remained active through its design, development, and deployment in the following edition as instructors. Here they describe, for the historical record, the motivation, sequence of activities, successes, and obstacles felt over two years since the first idea concept until a fully implemented model involving a symbiosis between companies, University, and students of Industrial Engineering and Management.

Throughout this paper, it will be understood how important it is for companies to be involved in University initiatives related to LSS and the impact of hiring graduates with Green Belt knowledge capable of stimulating change in their organizations. Secondly, the authors will go through the importance of creating free and easy access to LSS knowledge to provide a higher quality of education, in Universities, and, ultimately, to better prepare the next generation of leaders.

Afterward, it will be shown how this course was adapted to the University of Minho educational context and, finally, what were the direct results on the students, the University, and the corporate partners involved.

The authors will present their vision to provide a scalable LSS Green Belt course structure integrated into the Industrial Engineering and Management educational curriculum, given by students (Green Belts, and, hopefully, one day also Black Belts) to their peers. By joining the Green Belt course and using the LSS method in an internship in a company, students have the chance of obtaining a Green Belt certificate given by ESTIEM and signed by Gregory H. Watson himself, before their graduation.

This work does not aim to improve the existing literature, but rather to describe a practical case study of how engineering curricula can be enhanced when students and teachers collaboratively work

towards filling gaps on the existing teaching methods, is based solely on the real-life experience of the authors as instructors of the course. The authors aim to show the benefit of encouraging and promoting such courses in the preparation of students for their future challenges, but also in a closer connection between students and teachers that is believed to lead to better education and understanding of the subjects.

BACKGROUND

It all began with ESTIEM - most important European Association for Students of Industrial Engineering and Management, along with Gregory H. Watson, in an event called Summer Academy - one of the many events that ESTIEM organizes and offers to its students. In that event, the concept of LSS was brought to discussion and a participant got interested in this methodology and took the Green Belt course that same summer (Jarrett, Matti & Rajala, 2016).

The following summer, Gregory and Jukkis (the participant mentioned above) began thinking about how they could start building a Green Belt course for ESTIEM and its members, by focusing on a never worked on a gap in the LSS education industry - students. They had the vision to make a high-quality Green Belt training easily accessible to Industrial Engineering and Management students from around Europe and equip them with tools to solve even more complex problems in companies before they are even graduated, which would allow them to be better suited to enter the job market and lower companies' training costs to new hires. The idea was for Gregory to build the course content and the students to be deploying and expanding it in Europe through ESTIEM's network. To do so, the course's content was to be presented to participants through videos where Gregory would explain all the concepts necessary. The team developing the course, along with Gregory, filmed and edited 80 videos, whose length varied from 4 to 20 minutes, depending on the content and complexity of the subjects being presented.

It was time to present the course to the whole ESTIEM community. It happened in Council Meeting Porto 2016 – ESTIEM's general assembly where students from all member Universities vote on matters relevant to the future of the student association, where the council voted to launch the LSS Initiative for ESTIEM. The first ESTIEM LSS Green Belt Course took place at Aalto University in November and December 2016. After that many other courses were given across all of Europe.

The result of all this process was a full week course with a blended approach between theory and practical lessons (Turtiainen, Rajala & Jarrett, 2017), being the first one shared with the students through multiple videos and practical sessions facilitated by ESTIEM Instructors, that already had

done the Green Belt Course. After that week, the participants must have to complete a Green Belt Project on a company to get the final certificate of Green Belt in LSS.

STRUCTURE OF THE UNIVERSITY OF MINHO'S GREEN BELT LEVEL COURSE

Two years ago, after realizing the potential of these courses and seeing how many people from our university was interested to take the Green Belt Course and analyzing the industry surrounding our University and their demand for highly talented students, the authors have decided to design our own Green Belt course, leveraging on the already existing ESTIEM's structure, but adapting it to the Portuguese educational context. On a high level, teaching the course can be divided into three individual components: 1) teaching the theory, 2) facilitating training sessions and case studies, and 3) project monitoring (Turtiainen, Rajala & Jarrett. 2017).

To start designing the course the authors had all the needed resources to do so: 5 ESTIEM Instructors, support from our local Industrial Engineering and Management Student Association, and our University department and a corporate partner interested in being involved in training future quality professionals. With the help of ESTIEM, the authors developed a free 10-Week Green Belt Course where participants had to see weekly webinars with the theoretical Green Belt knowledge. Additionally, they had to attend a weekly 4-hour practical session, where they would put into practice the tools they learned in the webinars. The course finished with a final case study - a simulation of a real-life LSS project in which they applied the contents they learned throughout the 10 weeks.

This structure as the global teaching methodology used in ESTIEM translated the cognitive domain of learning to the context of the course. Rather than seeing the learning journey as a step-by-step process, the model is built on the premise that sufficient knowledge on the lower levels is a prerequisite for better uptaking more complex higher levels of knowledge. Following it, the instructors aim to enhance the ability of the students to recall what they've learned about LSS in the previous DMAIC by bringing real case studies to class; to apply the topic onto an actual problem in a structured way; to synthesize their action plan by selecting from a panoply of quality tools the best ones for the context at hands; and, ultimately, to stimulate the ability of the student to clearly understand the impact of each tool in a real-world context, which is mostly gained in the case studies presented throughout the course, but most importantly during the internship to achieve the green belt level certificate.

One aspect that was always considered from the beginning was the sustainability of the course. Considering students are leaving every year and new students arrive, it was seen as crucial to

guarantee that new students were available to pick up where others had left. Therefore, in the two editions, 3 to 5 students were selected to attend the course and to step up and play their role of instructors in the following year. To guarantee the quality of the courses, ESTIEM developed a mentoring system for the trainers. It currently has special programs for want-to-be trainers where black belts share facilitation skills and dive into deeper LSS knowledge, mostly focusing on more complex statistical concepts. This method avoids a spiral flawed guidance effect which could compromise the sustainability of the course in the long-run. It assures the authority of the trainer is preserved, assuring high-quality standards of those involved in teaching every year. To achieve so, trainers are taught how to handle difficult situations that can arise during the teaching sessions, and receive coaching to fully grasp the content of the course. Besides, the content of the ESTIEM LSS course is standardized and built so that the students can facilitate them with sufficient confidence. This minimizes the potential variation in the learning of the course content, which could be introduced by changing the instructors. As the learning material is maintained, as well as the examples and case studies, quality is guaranteed every year regardless of who leads the teaching.

Regarding the preparation of the classes, the instructors, being handed the materials by ESTIEM, have adapted them with their knowledge on the subject, but also adding a strong practical component and real-life applications. This was made by researching real case studies of the application of LSS to several problems, from healthcare to operations, or software development. The goal was to tackle a problem pointed very often by students to education: the lack of real-life situations where techniques can be applied. Every class, a real LSS project was brought to students to review the content taught in the previous classes. This was done throughout the entire course.

Even though the authors developed a conceptually impactful project, the implementation roadmap of the course was crucial for it to turn into a success. To reach the best students at our University and make them interested in a 10-week course about a tool they did not fully understand, the authors partnered the course with two different and important partners: The University of Minho and LSS-driven company. Regarding the University, the authors integrated the training course into the course of “Advanced Quality Engineering and Management”, which is taught in the fourth year of the Industrial Engineering and Management Integrated Master Program. This meant that the students taking this subject had priority to do this course and their participation was valued in the final evaluation. Regarding the partnership with the company, they supported all the costs regarding materials needed to do the sessions and gave the students the opportunity of visiting the company and to implement what they learned on a real company problem, with the help of two black belts and one master black belt running the factory plant.

It is important to note that the authors, being students, are aware of the flaws pointed out by their peers concerning their teachers. Knowing this, the instructors have tried to avoid and improve upon those flaws, especially in the teaching method and approach to content.

RESEARCH METHODOLOGY

To frame the evaluation of this innovative method to teach an LSS course, the authors followed the hypothetico-deductive method, creating strong hypotheses that were tested through direct observation from all the actors involved, the students that enrolled the course, trainers, companies, and teachers. To do this, the authors gathered not only their opinion, but also the opinion of teachers, students, alumni, and companies. This was made by promoting questionnaires and interviews with parties involved.

The hypothesis presented and explained below were created considering all the stakeholders that played a role in this course, ensuring that the methodology chosen would have enough opinions from people who have experienced it to validate the author's assumptions.

Hypothesis 1 – Does the LSS Green Belt Course benefit the students?

Throughout the years, the idea of an engineer faced many changes. Before modern times, engineers were classified as problem solvers with an excellent mastery of technical skills and knowledge. They needed to fully understand the technical context around their work or product, and they were easily stereotyped regarding a specific industry, product, or service, specializing in a specific topic. Nowadays, this idea of an engineer has evolved and grew into a much more complex concept. Today, they are not problem solvers but also problem finders. They need to identify, evaluate, formulate, and solve problems with people from other scientific, technical, and artistic areas and from other cultures. They need to understand much more than the technical context around their work or product. Currently, they combine their technical skills with so-called soft skills. In the age of information, it no longer matters what one knows, as information is accessible to everyone, but rather how one is capable of filtering data to efficiently find answers.

Based on this, the authors believe that the LSS Green Belt course that was about to be implemented could bring a really big impact on students' development since this course incites the participants to lead and work with a team in projects to identify and solve problems. By teaching a problem-solving framework like DMAIC with useful and impactful tools allied to each phase could provide a lot of

opportunities for students to participate and engage in better projects, better companies, achieving better results in the end.

In short, the implementation of this course would allow students to be more prepared to face their professional careers and to be more motivated to incite change inside organizations.

Hypothesis 2 – Does this new approach incites change in Universities?

The word “University” was once upon a time referred to as the lighthouse for knowledge, illuminating the way scholars, students, teachers, had to go through to be able to defy present dogmas and create new concepts.

The problem is that the times the authors are living intend to be in constant change, where nothing is seen as static anymore. More than ever Universities are lagging what the future of the industries are looking for, with its pillars set on old teaching models built for mass production and not innovation management. The authors are conscious about the difficulties to follow side by side with what enterprises are doing, mostly due to resource constraints, but there is where complement courses can have a vital action, providing educational institutions a boost on their transformational path to build the defiant of tomorrow and not the worker of today.

Our hypothesis lies in the belief Universities gain external recognition as producers of excellent students and professionals by giving students the chance of acquiring important knowledge for companies and institutions without any costs.

To test this hypothesis, teachers and partners of the ESTIEM LSS course were interviewed, highlighting professor Paulo Sampaio, who was one of the main responsible for bringing this unique LSS Model to the University of Minho in a unique structure; and Christoph Hagedorn, who holds the position of Head of Corporate Quality & Environment at Continental. Both will give their personal and institutional points of view regarding the importance of leveraging methodologies like LSS, integrating them into the University’s curricula.

Hypothesis 3 – Does this innovative course incites change in Companies?

Nowadays companies are facing a diversity of challenges, most of them never faced before. The agility that is needed to overcome those obstacles is increasing exponentially in recent years. At the same time, they are facing those transformations, they are also competing for the most talented and prepared graduates.

The University of Minho is at the center of an industry-based region in the north of Portugal and so, the need to improve and polish processes is always a must. The problem was that those companies were not able to find the best human resources with the data-driven problem-solving skills needed, due to the theoretical approach the University curricula still keeps. To tackle these companies are spending a lot of money on training courses focused on tools they should already have acquired during their academic years.

By understanding all these problems, first contacts between the founders of the course and enterprises were made to understand how the practice sessions should be to prepare the students for real-life cases and to benchmark with existing corporate certified training courses on LSS.

In theory, with this course companies would have access to employees with problem-solving and process improvement skills like never before. When you are betting on continuous improvement, in the long run, this kind of talent is critical. Besides, the Green Belt Course would have a huge impact on lowering onboarding costs.

Regarding the students, the authors assumed that they would be better prepared for the professional future and, when it comes to recruiting, they could have an edge over the others.

Having the opportunity of being certified in a methodology so much valued by the leaders of the industries still in their academic path is unprecedented in the Portuguese educational context.

RESULTS

Result 1 – Benefits for Students

After 2 years of teaching students LSS, the authors ended up with an exceptional number of 63 students with the Green Belt level of knowledge.

After the course they had the skills to work inside a specific work process, to assure standard work, to lead correction of non-standard work, and to encourage and lead work process improvement, always project and teamwork-based.

Accordingly, to what the authors expected, the students developed both hard skills and soft skills with this course, making them even better and more prepared engineers with competencies valued by the employing companies. During the time as trainers, students also deepen their knowledge of the LSS, as well as get valuable experience in facilitating group work, learning, and teaching. The skills and experience they gain during their instructor journey will be very valuable in a business context.

Finally, the interest of working in this field of Industrial Engineering and Management and the number of projects has increased throughout the 2 years. By the end of the first year, 6 students decided to do their master thesis on Quality Improvement and Management and, after these 2 years, more and better projects, internships, and master thesis were presented to students (the numbers will be presented later in the article).

Result 2 – Benefits for the University

LSS is all about having a framework that allows anyone who masters it to, in a methodical and simplified way, question their context and, step by step, with a specific tool-kit, iterate on their hypothesis to find solutions capable of improving whatever they set themselves to improve. In the end, providing nothing less than excellence to the customer is the goal.

The implementation of this 10-weeks course, worked as a valuable addition to what was already being taught in the quality management field at the University of Minho, giving a world-recognized methodology with no costs to every student in the penultimate year of Masters in Industrial Engineering and Management. This allows the students to be better prepared for their master thesis projects, and to apply for the company's vacancies with a Green Belt level already acquired, before finishing the course.

In the eyes of the companies, the University is capable of training better graduates, who will afterward show higher levels of performance in comparison to other students, as they are more prepared to face different problems in a structured way.

Concerning the tight relationship with enterprise and its impact to the overall quality of the course, the knowledge shared and leveraged to structure the course according to the best green-belt level practices in the industry were paramount for the course success, especially when looking to the training skills of the students sharing LSS content. Often, the atmosphere in the training sessions could become a bit tense when the students started asking questions beyond the standard teaching scope, questioning the competence of the trainer. To tackle this situation the course' partner company knowledge was very valuable to hold the reigns of the course, better preparing the trainers to answer doubts about broader topics than those listed in the original, standard course curricula.

Over the last two years, the authors provided LSS Green Belt level knowledge to 63 students without any costs, in addition to company visits, and real-life case studies to test the content acquired during class.

Testimonials regarding the impact the course has on Universities

How do you value the ESTIEM Lean SS Course?

“This course is a great opportunity for the Industrial Engineering and Management students for two main reasons: (1) they have the chance to learn one of the most well-known methodologies for process improvement, thus allowing them to go to the companies with that knowledge when they graduate; (2) during the course they have the chance to see and study real-life examples of LSS projects, thus promoting the link between academia and industry.”

How do you value projects coming from graduates of the course?

“To graduate students must develop an applied project in a company for 9 months. After the ESTIEM LSS Course was established at the University of Minho, the number of LSS project proposals by companies had increased, thus reflecting that the companies are recognizing the quality of the training that is provided to the students through the ESTIEM LSS Course.”

How important was to integrate this course into your quality management track?

“I teach a course of “Advanced Topics on Quality Engineering and Management” and since the first minute that I'm enthusiastic about this “partnership” with ESTIEM by integrating the LSS course in my track. It was possible to teach LSS without this partnership as I have done for several years, but it was not the same. Currently, I have students teaching other students and it is resulting in a great experience.”

Professor Paulo Sampaio, Professor of Quality and Organizational Excellence in the Department of Production and Systems at the University of Minho

How important do you think it is to integrate more of these complement courses in University curricula?

“Looking at a large corporation it is nearly an impossible task to train the entire organization in structured problem-solving. As such training needs theoretical knowledge and practical application it is only in selective cases possible to integrate this in the daily work. Therefore, learning and applying the LSS methodology already during university time makes each graduate of such a course a much more valuable employee for any company. They bring a piece of knowledge and mindset that every company is looking for. Having such a course is in my eyes a perfect win-win situation for the student, the university, and the companies.”

Christoph Hagedorn, Head of Quality in Continental – partner of ESTIEM LSS course

Result 3 – Benefits for Companies

The Lean Six-Sigma Green Belt Course was all about teaching students how to apply the DMAIC framework, analyze problems, collect information, and provide solutions based on data that could help companies to perform better and to save costs.

After two years, the results have gone beyond our highest expectations. It was created a partnership between a leader in the automotive industry where the students can solve a real case-study in the company for one day and finish the course with a hands-on immersive experience with black-belts and master black-belts. Ten students already realized three to six months projects (internships or master thesis) where they applied the knowledge acquired from the course in five different companies from different industries (automotive, healthcare, metal related sectors). Furthermore, the companies were able to have outstanding results such as eighty thousand euros indirect savings and forty percent fewer activities necessities in requiring an ambulance for patients in a public hospital; forty-two thousand euros saved a year in a metalworking automotive company; decrease by 30% the defect units in an electronic automotive company; the decrease of quality costs and increase customer satisfaction were some of the results driven by the projects our graduates started. In total, the financial impact of the LSS projects rounds up to almost 130 000 euros.

Unfortunately, the authors were not able to collect qualitative information from companies who have received the graduates from our LSS course, but the feedback from our partners was nothing but positive.

Companies are conscious of the impact of going beyond the normal standards of engineering education has on real-life cases and the integration of new hires recently graduated from University.

Testimonials about the impact of the course on companies

What does it mean for students to able to acquire LSS knowledge so early in their careers?

“Learning LSS methodology has opened doors for students to perform projects, which they would not be given otherwise at that point in their professional career. This reflects the importance of training undergraduates in problem-solving frameworks.”

Jukkis Turtiainen, LSS Black Belt and Founder of the ESTIEM LSS course

How do you value the ESTIEM Lean SS Course?

“The LSS course is a great opportunity for the students as well as the companies that offer them a project. The students learn a structured problem-solving methodology that allows them even as young professionals to achieve results experienced colleagues could not achieve. Thus they become a great asset in any improvement project, develop confidence through the success of their project, and learn to trust the method and follow the facts. This will make them a very valuable employee for every company that sees continuous improvement as a key cultural element.”

How do you value projects coming from graduates of the course?

“The graduates from the LSS course employed by Continental have exceeded our expectations. In a recent project, the student achieved within four-month to generate an annual saving of more than 3 times the cost. So, it was a perfect investment. Continental will continue to offer projects to LSS graduates.”

Christoph Hagedorn, Head of Quality in Continental – partner of ESTIEM LSS course

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CONCLUSIONS

Over the last two years, the authors provided LSS Green Belt level knowledge to 63 students without any costs, in addition to company visits, and real-life case studies to test the content acquired during class. Eight of those students were on their final year of bachelor and became ESTIEM instructors which gave sustainability for the years to come. The other 55 were in the first year of their Master's Program and they were presented with the opportunity to complete their thesis on an LSS project.

The goal of this article was to take the reader into the journey the authors took, once upon a time, and understand how to design a scalable LSS Green Belt level course in their own companies or institutions, by leveraging on our personal experience of diagnosing our client’s needs (in this case the students, university and industry around us) and creating a 10-week course from scratch aligned

with the best courses of its kind in the world. By the end, it is about the impact of democratizing access to such a costly certificate, only acquired when one already has two to three years of experience, by implementing a teaching model blending theory with practice, with students teaching students, and endorsing the LSS movement.

This course not only gives students a structural way to solve problems but also opens future opportunities: they graduate more prepared to face the business world and they get better offers from better companies.

However, this project did not affect only the students. This Green Belt Course, by being associated with a University course, impacted the way knowledge was being shared and acquired in our degree, by putting the student at the heart of learning experience. By the end, students are not only receiving information but also, after taking the course, they have the opportunity of becoming trainers.

Finally, by implementing the LSS concepts based on the DMAIC cycle, students changed organizations' decision making and operation processes, by evolving to a more data-driven and quantitative approach. Not only these projects prove how students can change the organizations but also make the companies understand how impactful LSS can be to their activities and results.

Now, going back to the question made at the beginning of the article: how can the authors adapt and prosper in such uncertainty? By embracing and inciting change, and LSS has an important role in this pathway that companies and institutions must undertake. LSS, by being a problem-solving methodology based on projects focused process improvement, sets itself onto finding new, innovative, and impactful changes to scale upon the organization to higher levels of quality and efficiency. Implementing this university project not only introduced in a deeper way the LSS topic to engineering students, endorsing the methodology but also trained students to embrace, incite and manage change within the companies they will work in the future. By making LSS Green Belt knowledge easily accessible for these students, the authors gave them another tool to help them to think and question the world around them, and to look for great answers to take organizations to the next level.

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