Chapter 3
Lean Education in a University in the Philippines

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3.1 Introduction

Lean education is paramount in the practice and pursuit of high productivity, efficiency, economic gain and sustainability, not only among engineering graduates but even among professionals. There is a vital need to educate engineering graduates because they are at the forefront of product, service and systems design. "Lean" is a mindset that needs to be inculcated in the students' thinking processes so that when they join any organization thereafter sustainability practices become second nature.

Engineering educators are faced with seemingly impossible challenges in the 21st century (Flumerfelt et al. 2015). They are expected to prepare today's millennial generation (Strauss and Howe 2000) for work in companies that make up our global society using an educational system that should continuously evolve to meet the changing needs of industries and societies.

Lean Engineering Education (LEE) is one of the service courses of Industrial Engineering (IE) at the De La Salle University. As the gatekeeper of continuous improvement and robust standard processes, IE offers LEE to all engineering degrees. In the undergraduate levels, Total Quality Management (TQM), the basic principles of Lean Manufacturing, is a required course content in IE, as mandated by the Commission on Higher Education (CHED) in the Philippines, embedded under the CHED Memorandum Order Number 15 issued in 2008. TQM is also incorporated in all engineering degrees at the University. LEE is introduced at the undergraduate levels in courses such as production management and human

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behavior in organizations. At the graduate level, LEE courses such as Lean Manufacturing and Design of Experiments are offered to all engineering degrees and are required in the MS Industrial Engineering degree.

The De La Salle University's engineering program consults a board of advisers from industry about their current needs which are incorporated in the design of program objectives, expected graduate attributes (EGAs), program outcomes and learning outcomes. The Industrial Engineering (IE) Program's educational objectives (PEO) are three-fold: (1) leadership, (2) life-long learning and (3) social responsibility. DLSU-IE graduates will assume leadership roles in the practice of Industrial Engineering and its allied disciplines of manufacturing, service, business enterprise, and government (PEO (1)-Leadership). They will continue to be engaged in life-long learning, understanding and applying knowledge and ideas in industrial engineering and allied fields (PEO (2)-Life-long Learning) and will become informed and involved members not only of IE professional society/ies or other professional organizations but also in community-based organizations (PEO (3)-Social Responsibility) (Li and Siy 2014).

Developing a mindset of lean manufacturing amongst practitioners is one of the goals of the industrial engineering program. One of the student outcomes (I: Life-long Learning and Keeping Current) is the ability to engage in life-long learning and an understanding of the need to keep current of the developments in the field of discipline (see Fig. 3.1). Coupled with Student Outcome H which is Systems Thinking (an understanding of the effects of engineering solutions in a comprehensive context), the industrial engineer is expected to be well-informed of the current evolving needs of industry and society and to create solutions that address these needs.

Philippine companies put a high premium on engineering graduates who have a working knowledge of lean manufacturing. Later, when these graduates earn more advanced accreditations in Lean Six Sigma proficiency (e.g. green, black, and master black belt degrees), they get more chances at being promoted to higher positions in the company.

At the outset, Lean has been identified as a jump-off point for green initiatives and sustainability. The practitioners and experts on lean manufacturing have seen the potential of lean practices in the whole chain of anthropogenic activities [e.g. lean consumption (Womack and Jones 2005)]. The specific values that the student is expected to learn include an appreciation of the complexity of Lean manufacturing production lines and efficiency differences in terms of the various factors of production—man, machine, materials and methods among traditional and lean manufacturing systems.

By virtue of the nature of the systems discipline of IE, environmental sustainability, sustainable production and consumption are allied disciplines. The current state of the art in the analysis of systems is highly utilized in understanding sustainability in its various levels and dimensions of agglomeration.

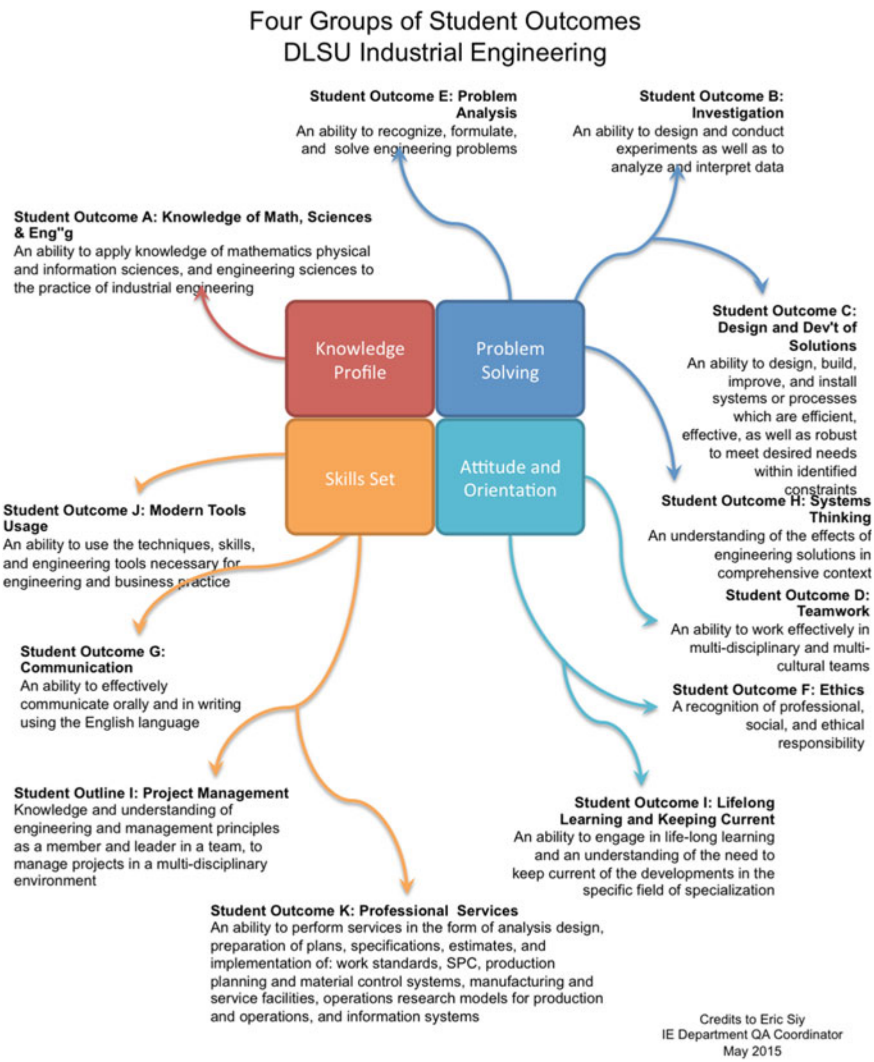

Fig. 3.1 Four groups of student outcomes in DLSU Industrial Engineering

De Rosnay (1979) in The Macroscope masterfully designed a conceptual framework of the whole economic machine highlighting the various linkages amongst cells, organisms, individuals, resources, and societies, that contextualizes extraction, production, consumption and disposal activities that make up global sustainability systems.

3.2 Pedagogical Framework

The Experiential Learning Theory (Kolb 1984) underpins the theoretical support to the pedagogical methodology. Experiential learning comes from actual practical experience which leads to a reflection on what has been seen, experimented, felt, experienced and recorded. This reflection leads to learning, understanding, and the desire to try again, experiment further and understand deeper.

The Lean courses in the undergraduate and graduate levels are based on iterative rounds of the Lean production structured learning exercises that alternate with short lectures, cases and video presentation on Lean topics. The experience and application of each tool individually help to increase the knowledge and skills levels regarding its main technical implementation aspects and scope. As designed, due to its modular structure, this course relies on Lean tools configured to address different learning needs of the students. More specifically, the structured learning exercises (SLE) are implemented as follows:

1. The Lean course starts with a first round of the Lean production structured learning exercises after students form learning groups or teams, acting like corporations engaged in manufacturing representative products, usually a simple and easy to assemble product.
2. After that round, team members compute and measure Lean Key Performance Indicators (LKPI's) for the corporation (corporate level KPIs) and the individual (individual KPIs).
3. Teams formulate problems and/or make suggestions for improvement.
4. To assist the team in fully understanding the problem and providing the team with an appropriate improvement tool, the teacher lectures on the related course module.
5. Using a problem solving methodology learned in previous courses, the team members use this knowledge to find the most appropriate improvement actions.
6. As soon as the whole team agrees on the actions to be taken, they implement them in the Lean production structured learning exercise by changing the structured learning exercise setup. Then, the team is ready to play a next round and a next learning cycle begins.

In the undergraduate junior program, students become familiar with the fundamentals of production management. Students who enroll in an elective course on production management (PROLEC1) learn more about factory physics and lean manufacturing. This is further reinforced by enjoining students to join groups in a project study to be completed in one term as required by the course.

The topics of PROLEC1 are designed to address the needs of the industry to enable the students to apply Lean Principles in their project study, at least at the introductory levels. Upon completion of the term project study, students are required to make presentations to owners and managers of the host companies.

At the graduate level, the scope, depth, breath and intensity of the topic discussions are further reinforced by more advanced case problems.

3.3 Lean Projects

The student groups scouted for companies to work with for their term project study.

But more than simply teaching Lean principles and tools, the course also aims at developing a Lean mindset. This means there is a lot of attention to and feedback on the Lean behavior of the students. In order to enhance the output quality, the authenticity of incorporated cases and the relevance of all material included, other external experts from the industry are involved in the project, especially those faculty members who have been serving as consultants to various companies.

3.3.1 Design of the Course

The Lean Manufacturing course covers how the Lean Manufacturing philosophy and techniques can be applied to an organization to maximize customer value, minimize waste and reduce costs. By adopting a Lean Manufacturing approach, a company will become faster and more responsive to customer requirements while using fewer resources. As a general course objective, the student by the end of the term, should be able to achieve multiple goals such as:

1. Learn how a company can transform a traditional manufacturing firm into a Lean manufacturing system by focusing on material flow and lead-time reductions;
2. Learn how to take advantage of the benefits of Lean techniques through the demonstration and application of Workplace organization and visual controls, Standard Work, Cellular manufacturing, one-piece flow, Systematic Layout Planning, Quality Management Systems, Pull systems, Kanban, Point of use storage, Continuous Improvement; and
3. Illustrate the applicability of these concepts in the Philippine setting.

This is an overview course for the Lean Manufacturing discipline. It focuses on the tools, techniques, concepts and principles of Lean. While most of the emphasis is on the manufacturing environment, examples from administrative functions in the service sector are also used to explain key concepts.

3.3.2 Syllabus of Lean Manufacturing, Graduate Level

The plan of teaching content is contained in the syllabus, such as in Table 3.1.

Table 3.1 Syllabus

Week	Topic/details
1–2	**Laying the foundation** This is an introduction to the basic principles and concepts of Lean Manufacturing. The teacher gives short lectures and will lead students through a basic factory simulation (hands-on) that will demonstrate how Lean can be used to dramatically improve productivity
	Overview and Introduction of Lean principles/concepts/tools Context of Lean (green/sustainability) Principles of Lean Manufacturing Stockless production (video) Kinds of wastes Factory simulation (hands on, short demonstration) Building a practical lean strategy that works *Readings*: Lean Thinking, Part I by James Womack and Daniel Jones (Womack and Jones 2003)
	Upon completion of laying the foundation, **students will be able to**: • Know the origin, history and emerging trends of lean manufacturing • Learn its basic philosophy • Identify the critical factors for a successful implementation
3–4	**Lean leadership and the tools of lean manufacturing**
	Lean Production at a Company (video) Process centered organization and change management Getting started with lean 5 S: 5 step approach to developing safe, clean and organized working environment Kaizen/continuous improvement The visual factory Mistake proofing/defect prevention
	Readings: Lean Thinking, Part II by James Womack & Daniel Jones (Womack and Jones 2003)
	Upon completion of 5S/visual factory, **students will be able to**: • Define the five S's • Describe how 5S activities are linked to bottom line measurements • Use visual signals to speed the decision making process • Understand the importance of developing standards for visual systems
5–7	**Value stream mapping (VSM) and analyses**

	Mapping the Entire Value Stream for the Enterprise
	    Current state
	    Ideal state
	  Analyzing the value chain
	  Transformation methodologies overview
	    Pull systems
	    Standardized work
	    Continuous flow
	    Error proofing
	    Setup reduction
	    Total Productive Maintenance (TPM)

	Readings: Learning To See by Mike Rother and John Y. Shook (Rother and Shook 2009) Design and Analysis of Lean Production Systems by Ronald G. Askin and Jeffrey B. Goldberg (Askin and Goldberg 2002)

(continued)

Table 3.1 (continued)

Week	Topic/details
	Film Showing: Value Stream Mapping *Case 3*: Value Stream Maps (current and ideal states), Spaghetti maps
	Upon completion of value stream mapping, **students will be able to**: • Learn how to map out current and ideal states of companies and value chains • Analyze value-adding and non-value-adding activities and relate these to takt time • Determine sources of waste • Identify optimal transformation strategies
8–9	**Lean tool-box**
	Set-up time reduction Fundamental principles of waste reduction Barriers to reducing set-up time Shingeo Shingo's Single Minute Exchange of Dies (SMED) Rapid changeover Process flow improvement techniques Pull systems (pull versus push product) Standard Work Line Balancing
	Upon completion of Lean Tool Box, **students will be able to**: • Define the setup reduction process • Identify opportunity areas for setup reduction • Learn how 5S/visual factory positively impacts setup reduction • Determine which tools are more appropriate to use when designing leaner systems
10–12	**Creating continuous flow manufacturing** Students will learn how manual and machine operations can be linked to increase efficiency while minimizing transport and delay. These concepts will then be used to explore a step-by-step approach to design and implement a flow line (cell). A video on the visual factory is used in this module.
	Linking and balancing manufacturing operations Design and implementation of continuous flow cells Creating the flow Seeing the whole (extended value stream mapping) for the Supply chain
	Readings: Seeing the Whole and Creating the Flow, Dan Jones and Jim Womack (Jones and Womack 2011) Video: visual factory
	Upon completion of Creating continuous flow, **students will be able to**: • Determine product families that qualify for manufacturing cell layout • Determine production capacity by process • Analyze cell loading based on customer requirements • Design an effective manufacturing cell • Calculate new takt time and balance work based on customer requirements • Complete a standard work sequence sheet
13–14	**Integration**

3.4 Hurdles Encountered

A number of hurdles are normally encountered, the most difficult of which is getting started. Matching the groups with a willing company embarking on Lean initiatives proves to be the hardest. This usually takes a week or two from the start of the term. The teacher ensures that the specifications are discussed thoroughly at the very start of the term and a company profile is submitted at the immediate succeeding meeting to ensure the students aggressively convince the host companies to divulge data and consider Lean Exercises and be a part of the program. There is no requirement for the company to implement the results of the term project. As soon as this is done, the next difficulty is how to encourage the companies to fully divulge their data and systems to the study groups. This is easily addressed by issuing non-disclosure agreements with the host companies and giving them an assurance that only the faculty members will have access to their data and findings. In cases where they wish to be hidden behind a pseudonym, the groups comply.

3.5 Student Outcomes

As part of the experiential learning method applied in the course administration, we receive feedback and evaluation from the students at the end of video presentations, structured learning exercises, cases, problem sets and the course.

Box 1 shows an excerpt from a student's reaction paper after the structured learning exercise.

Box 1. Reaction to a Structured Learning Exercise (SLE) Academic Term 3, School year 2007–2008

"It was also said that there's a "discipline required to implement Lean and the disciplines it seems to require is so often counter-cultural, that makes successful implementation of Lean a major challenge". Individual examples of success and failure exist in almost all fields of business and activity and therefore cannot be taken as indications of whether Lean is particularly applicable to a specific part of activity. It seems clear from the "successes" that no part is immune from possible benefits.

They also directed us to perform a game to simulate a production system and made us think on how we can apply Lean concepts to improve the system. I think this is a good way to give us a first hand experience on implementing it. You can visualize more where the value and non-value adding activities, where the bottlenecks usually occurred, the importance of different tools and techniques such as Kanban.

The most important point I have learned with the lecture is that the most common mistaken approach in using Lean is to focus on maximizing activities that are value adding in the whole process*, *then most non-value adding activities are being overlooked. *They emphasized that although it is important to maximize value adding activities, it is more important to properly identify and eliminate non-value adding activities in the processes to make Lean more successful."*

Box 2 is another student's reaction to the entire course implemented over one term.

Box 2. Reaction to the Lean Manufacturing Course (IEN532M) Academic Term 2, School year 2008–2009)

"This is a reaction paper for the just concluded course, Lean Manufacturing (IEN532M), under the programme Masters of Science in Industrial Engineering of the College of Engineering at De La Salle University. The course was taken on the 2nd term of school year 2008–2009 under our professor Dr. Anna Bella S. Manalang. The aim of this paper is to state the most value adding element of Lean (in terms of benefit) together with its areas for improvement in terms of the different approaches.

Lean Manufacturing

The course started with the lecture on Lean concept. I think the idea of lean manufacturing is not totally new. Lean manufacturing seeks to look for waste and inefficiencies and eliminate them. Anything that does not add value to the functionality or quality of the product should be removed from the production process. The goal is to continuously improve and shorten the processes.

There were two major approaches to Lean that were retained in my mind. First is the identification and elimination of waste through the use of different tools. This approach can help improve the quality and can reduce production time cost. These tools were Value Stream Mapping, Five S, Kanban, and poka-yoke. The second approach focuses on improving the flow of work. This is where production leveling, pull production by the use of kanban, and the Heijunka box takes part. The implementation of smooth flow exposes quality problems which already existed and thus waste reduction comes next.

Benefits of Lean Manufacturing

The major benefit of Lean, most of the time, is the shortening of lead time from order taking to shipping. The work-in-process (WIP) inventories outside the cell is also much reduced and in effect, space is also saved. There's also a tendency to have a higher quality output because defects are discovered much sooner in the line. In terms of employee's culture, Lean promotes better team communications and "ownership" through cell set-up. The cultures are standardized, thus, unfavorable practices and behaviors of both the *employees and the management are reduced, if not eliminated. It also supports a demand "pull" operation that yields much better material control and schedule control compared to "push" scheduling systems.*

Areas for Improvement

Some of the disadvantages that can possibly serve as the areas for improvement in implementing Lean would be lower equipment utilization for non-bottleneck cell operations, unless multi-functional equipment is employed, and if there is no equipment redundancy within the cell, the whole cell may shut down when one piece of equipment goes down. An operator must also operate several different pieces of equipment that decentralized their expertise. Another observation was, if demand falls and production output is below the planned cell capacity, per unit manufacturing costs tend to be higher with some cells. This occurs when a good labor balance cannot be achieved at the lower output level. Any small subsequent changes in the production process or sequence could also have major changes on the cell layout and cell efficiency, sometimes there is more flexibility when using traditional departmentalized layouts. Finally, some multi-product cells are not suitable for higher volume orders where they may become a bottleneck to scheduling other parts.

Conclusion

For lean manufacturing to work best, everyone in the system needs to be more informed because the end result usually involves several manufacturers. If there is a communication breakdown, things will be less efficient.

At the end of the term, the most important point I have learned with Lean Manufacturing is that if a process in the manufacturing is being unnecessarily duplicated in supply chain members, it can be eliminated if it does not contribute to the value, function, or quality. A smooth work flow is the only way to get the best results at the lowest cost. This is all the more reason for cooperation within a supply chain. The value of lean can be realized only to the extent that the method is methodically implemented, it should be with depth and breadth throughout the organization, otherwise it will only be superficial."

3.6 Organizational Feedback About the Competencies of Our Engineering Graduates

The University through its Institutional Testing and Evaluation Office (ITEO) conducts a tracer study every two years of our engineering graduates. General responses from the industry, as validated by comments from employers, indicate that our engineering graduates are more preferred by many companies because they are more persevering, can work overtime, and can apply skills learned from the University very quickly on the shop floor.

The short-term successes are that they are able to conduct a full systems study on the lean host companies and design a full transformation strategy from the company's current to the future value stream map.

Some groups, under the tutelage of their professors, publish their findings with the consent of the host companies in conference proceedings and journals.

A handful of our graduates both in undergraduate and graduate levels pursue researches in the field of Lean Manufacturing in their undergraduate, masteral and doctorate theses.

3.7 Conclusion: Lessons Learned

A structured learning exercise simulation-based approach, coupled with lecturettes and videos with workshop, can be a powerful means of motivating students and improving experiential learning.

The students are able to reflect on their learnings and apply these real-life situations and actual companies, thereby creating an opportunity to get feedback from experts and company owners regarding the validity and feasibility of their lean transformation strategies.

More significantly, graduates of the course come out of the University with a Lean mindset. As such, they would have developed the potential to become change agents in increasing the productivity, efficiency, economic gain and sustainability of companies that will help these companies become more competitive. Overall, they have the strong potential to help in advancing the whole nation into higher levels of productivity, efficiency, economic gain and sustainability. Ultimately, they can champion global sustainability. It all starts with the Lean Mindset.

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