Integrated University-Industry Training: A Collaborative Journey

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Abstract University-Industry collaboration is fundamental in today's changing and competitive world, as it allows us to take advantage of the strengths of each of them. The University of Valladolid has been collaborating for more than 25 years with Renault-Nissan Consulting in different fields: scholarships, contract research and, more recently, a laboratory adapted to the academic and industrial environment, where Renault students and employees are trained to improve their skills in lean management. This school provides training in production systems concepts and lean manufacturing in an innovative way simulating real manufacturing processes. This work shows one of the latest and most innovative training processes carried out at the Lean School and the results obtained with a small product manufactured with toy building blocks and which is also carried out in companies on demand. The levels of assimilation and retention of knowledge of the students are highly superior to those achieved by traditional methods.

Keywords University-industry collaboration · Industrial engineering · Lean management

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1 Introduction

The need for permanent adaptation, of companies and organizations, to the changing and globalized environment, generates in those that achieve it through the adoption of creative solutions, an important competitive advantage. The new solutions, aimed at improving its operation, are directed towards the idea of generating value for its clients, eliminating from the processes everything that does not contribute value, which represents the basis of the Lean philosophy. That is why in the last decades the application of Lean Management in business processes has experienced a very significant growth. Lean Manufacturing is more than a system; it is a global production and management philosophy aimed at generating value at the lowest cost.

The growing implementation of Lean methodology in different sectors (aeronautics, banking, food, distributors, health, …), following the trail of the automotive industry pioneer in its application, has generated a growing demand for trained personnel in the same. Companies have been the first to detect this need, creating their own training environments, and demanding from Universities students trained in Lean methodologies and tools. Universities have thus been forced to adapt the curricula of engineering degrees, so that they include the acquisition of skills inherent to the Lean philosophy and the skills to make use of the tools that are part of the Lean environment. However, from the training point of view, in universities we have been slow in reacting to explain all these concepts in an active way involving students in learning, and not just being mere receivers of documentation. This change is also a demand from students since access to information in the twenty-first century has no similarity with access in past centuries. Considering all the above, the idea arises to implement a learning factory that integrates the main Lean management tools, allowing both students of the University of Valladolid and employees of companies access to experiential training.

To facilitate this change, at the University of Valladolid we have established a strong collaboration with one of the most important car manufacturers (Renault), so that once students have received this training they can do an internship at the company or at one of its Tier 1 suppliers.

2 University-Industry Collaboration

Globalization, the environment in rapid and continuous change, requires rigorous control of costs and markets, which has made both Logistics and the productive improvement of production processes, key tools to improve the competitiveness of organizations and ensure their sustainability.

Industry increasingly demand true specialists in the field of Operations Management, and significantly in the field of Production and Logistics. The top companies, in their search to reach the Excellence in the Operations and thus to obtain competitive advantage, rely on Lean Management.

Table 1 Organizational forms of UIC (based on [2])

Personal informal relationships	Individual consultancy, informal exchange forums and workshops, personal contact with university academic staff or industrial staff
Personal relationships	Student internships, sabbaticals periods for professors, hiring of graduate students, employment of relevant scientists by industry, or use of university or industrial facility
Third party	Institutional consultancy, industrial associations, government agencies
Formal targeted agreements	Contract research, cooperative research projects or training programs for employees
Formal non-targeted agreements	Industrially sponsored R&D in university departments, research grant and donations
Creation of focused structures	Innovation/incubation centres, research, science and technology parks

The "European Higher Education Area" promotes collaboration between universities and companies (UIC), understood as the mutual exchange of knowledge and technology through interaction. Its application allows to know the skills and capacities demanded from the labour market, bringing the training given in the universities closer to the business reality. This has been done for some time in numerous countries [1].

University-industry collaboration can cover different aspects and depths, and according to [2] can be classified into 6 large blocks (Table 1).

Renault-Nissan Consulting (RNC), the consulting firm of the Renault Group, has collaborated with the University of Valladolid for more than 25 years. The relationship began because several of the workers had been students at the University of Valladolid and knew and collaborated selflessly with professors giving some practical session at the university based on their professional experience.

After these first informal contacts, collaboration was increased with internships, company visits for students and the use of some laboratories for testing.

An important collaboration from the formal point of view was the participation of the company in the definition of new degrees within the European Higher Education Area (Bologna Process), a collaboration that has continued over time and has allowed the subjects to adapt to the real needs of companies in the region.

After this collaboration, which continues to be the same over time as the previous ones, collaborations arose with different research groups and participation in national and international research projects.

In the year 2014, this collaboration increased providing RNC and laboratory for the teaching of Lean tools to the students of the University of Valladolid. The collaboration agreement also includes the use by the company of the laboratory for the training of its employees.

This has allowed the University of Valladolid to be the first Spanish university to have a laboratory for teaching Lean tools using the techniques of "learning by doing" widely used in industry: Lean School (LS) [3]. To this end, an old chemistry lip has been transformed into a modern space made up of different workstations, warehouses, shelves, transport elements, etc., which allow participants to carry out active training, forming part of the training process beyond mere observation. In this way, students advance to be at the forefront of their training, as they must use learning methodologies in which the acquisition of skills, abilities and knowledge is done actively, through experimentation, participation, discussion, decision-making, etc.…

The laboratory can be used (in a coordinated way) both for the training of students at the University of Valladolid, as well as for the training of Renault workers, and even on some occasions jointly to favour the exchange of experiences and the incorporation of students in internships in industry. In order to maintain coherence and a standard level, university professors and company consultants participate in the training, thus ensuring a balance between the transmission of theoretical concepts and their applicability in different real situations.

3 The Training Process

In the laboratory (Lean School), the participants in the different formations face a productive process close to reality, in which they can apply the different Lean tools previously explained to them. In the case presented in this work we use the construction of different products, using toy building blocks. The objective of the training, once the main concepts of Lean Management (Pull, Push, Kanban, Kaizen, Continuous Improvement, Standardized Work, Balanced Work, 7 + 2 wastes) [4] have been presented, is to consolidate these concepts and apply different Lean tools.

The training is aimed at both university students and employees of the company or its suppliers. As the knowledge of "Lean Manufacturing" can be very different depending on their experience and/or university degree all participants take a small questionnaire (anonymous) prior to the start of the course in order to adapt the tools on which we focus during the course.

It consists of 3 sessions of 4 h (Fig. 1). Each session begin with a short theoretical introduction (45–60 min) followed by a simulation of a production process where the participants manufacture three types of products in the same productive area: Trailers, Tippers and Cranes. The product mix of customer demand is known, although not the order (40% trailers, 40% dump trucks, 20% cranes). The customer requests with a frequency and a defined delivery time and that do not change during the different productions. Each simulation begins with a short training phase so that the participants become familiar with the activities to be carried out in the different workstations: suppliers, sub-assembly manufacturers, logistics, warehousing, quality control and all of them led by a plant manager. Once 15 products have been manufactured, the participants fill in a questionnaire in which, after a brief reflection,

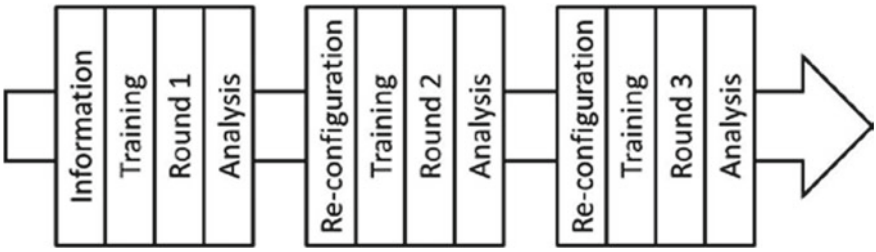

Fig. 1 Lean School training process

they discuss the strengths and weaknesses of the manufacturing process. With these questionnaires, the trainers summarize the results, placing special emphasis on all the problems that have appeared in the manufacturing process from the comments made by the participants and listing some of the Lean tools that will be used in the next manufacturing process to try to eliminate or reduce some of the problems.

Several objectives are intended to be achieved: practice on evolution process of manufacturing in "push" to one in "pull" discovering the benefits, experiment the concept of waste and how to eliminate them, discover the Lean logistics and Just in time concepts, understand the concept of takt time and the need to synchronize our production with it and analyse the concepts of manufacturing capacity and work balance. The analysis of the results in each session shows the practitioners the spectacular improvements that are achieved in all facets of the operational activity.

The three phases are characterized by the following:

1. The first production is carried out following a "push" batch production scheme: the suppliers manufacture components and sub-assemblies, the factory manufactures and logically demands material from the warehouse all 3 by 3.
2. After the first revision of the results (quite unsatisfactory), since only the vehicles were manufactured in the time foreseen for the opening of the factory, and moreover none of the 3 vehicles arrived in the time agreed with the customer, begins to study the balance of jobs (based on their knowledge of operations), improving logistics and reducing the size of lots (2 vehicles).
3. Finally, the third production is carried out through a flow of a single piece, after having continued to improve logistics and warehouse (from 3 people in the warehouse to 1) and balanced workloads over previous productions.

Table 2 shows the most outstanding characteristics of the three phases in which training is developed for 6 fundamental aspects: Lay-out, Production lot size, Transport lot size, Warehouse organization, Line balancing and Over processing.

Table 3 shows the positions occupied by the participants that are defined in phase 1 and how they evolve throughout the different phases. It can be seen that between phase 1 and phase 2 there is no reduction in personnel as the objective is to balance the workloads between the different jobs, define work standards and guarantee the manufacture of quality products (to avoid rework).

Table 2 Main characteristics of the different phases

	First production	Second production	Third production
Lay-out	• Two classrooms • First classroom: factory and two suppliers • Second classroom: warehouses	• Two classrooms • First classroom: factory and two suppliers • Second classroom: ware-houses	• One classroom Factory • Two suppliers and supermarket
Production lot size	3	2	1
Transport lot size	3 (1 between final assembly, quality and customer)	2 (1 between final assembly, quality and customer)	1
Warehouse organization	• Ordered by code number • Codes that are never assembled • There's a lot of stock	• Common Parts located in a sub-zone of warehouse • Small parts (codes 1–15) in workstations • Non used references are eliminated	• Zero stock in warehouse • Small parts (codes 1–15) in workstations • Components groups in supermarket
Line balancing	• Workstations very badly balanced • Much difference of work content among the four workstations of the factory	• Improved Balanced work content of factory workstations • Different distribution of work content of workstations 3 and 4	• Improvement in logistics operations by: – Reduction of work surfaces – Approach of warehouses, suppliers and factory – Kanban
Over processing	• The cockpit must be disassembled to fit another component • The crank must be disassembled to be reassembled on the tipper • Crank crane-chassis • Part attached to the "chassis"	• The three processes of 1st production are eliminated	–

In the different phases, the participants are shown the cycle times in each of the positions depending on the manufactured product. Obviously it is very difficult to make a perfect balance (in the same way that happens in the factories), and they have to learn how to make the balance based on the manufacturing mix (Fig. 2).

Figure 3 shows the results of delivery of vehicles to the customer. It can be seen that of the 3 vehicles delivered to the customer in phase 1 (out of time), 7 were delivered

Table 3 Jobs and functions of the different phases

Organization	Job title	First production	Second production	Third production
Manufacturing	Factory manager	1	1	1
	Wheels operator	1	1	1
	Cockpit operator	1	1	1
	Rear part operator	1	1	1
	Final assembly operator	1	1	1
Quality	Internal quality operator	1	1	0
Logistics	Internal logistics operator	1	1	0
	Warehouse manager	1	1	
	Warehouse operator n°1	1	1	1
	Warehouse operator n°2	1	1	
	Supplier transport	1	1	0
Suppliers	Wheels supplier	1	1	1
	Chassis supplier	1	1	1
	Customer	1	1	1

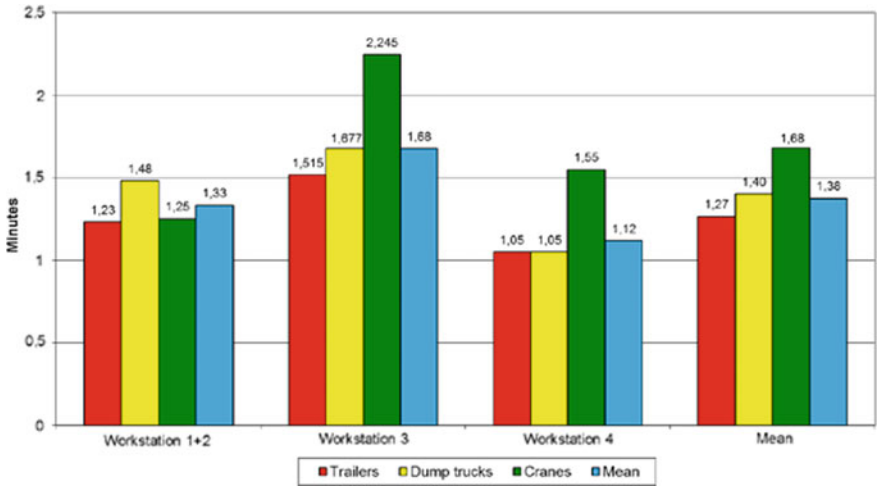

Fig. 2 Cycle time of the 3rd production in the different workstations depending on the product (trailers, dump trucks and cranes) and mean cycle time

Fig. 3 Dashboard with the results of the vehicles produced in the 3 phases

in phase 2 (although only one in time) and in the last phase the 15 requested vehicles were delivered (only 2 out of time and one with quality defects).

4 Main Results for the Learning Process

Participants are given a test of 26 questions divided into three main blocks: concepts (8 questions), principles (8 questions) and tools (10 questions). The test is carried out at the beginning of the training in order to know the level of the participants and to be able to adjust the level and the examples. Afterwards, the test is carried out at the end of each of the productions during the analysis period, although the answers will only be commented by the trainers at the end of the third phase so as not to influence the results (Table 4).

The trainers analyse the results at the end of each intermediate phase in order to reinforce those concepts that have not been sufficiently clear, although it is not an objective for all participants to answer the 26 questions well at the end of the training as they must be clear that there is always room for improvement and there are always concepts and tools to be learned.

Table 4 Percentages of correct answers in the tests

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Test 1	29	100	79	50	14	7	71	29	7	57	14	36	14
Test 2	100	100	100	36	93	57	79	93	43	71	43	36	29
Test 3	100	100	100	36	93	71	86	86	50	86	100	57	100
Test 4	100	100	100	71	93	71	93	93	86	86	100	79	100
	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26
Test 1	0	36	36	57	71	86	64	21	14	14	36	14	43
Test 2	0	29	43	64	86	86	57	29	29	21	57	21	71
Test 3	86	86	79	93	100	93	86	21	21	21	43	21	79
Test 4	86	86	100	86	100	93	100	79	100	93	100	64	79

5 Conclusions

At this point, we can identify two major blocks of conclusions. On the one hand, about this particular training, the participants who have carried it out (both students and workers) assimilate the concepts much better than when they are only explained in class in a theoretical way, because they have experienced the different tools proposed and have identified the results. In this sense, the satisfaction of all those who have done this training (both in the university and in business) has been very high not only in terms of learning concepts but also in terms of the teaching format. And the results obtained are very similar, regardless of whether they are students or workers, since the operations to be carried out are very simple (and this is where workers could have a certain advantage).

And the second big block of conclusions refers to the importance of university-industry collaboration where we can identify numerous advantages for both parties. The company identifies students with high growth potential in their factories, as well as being able to test different tools in different environments. On the other hand, the university provides students with training in current topics and adapted to new paradigms, which facilitates their incorporation into companies.

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