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The Lean thinking approach: Implementation in Moroccan engineering education

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Abstract: In the context of the global economic crisis, Moroccan engineering education is expected to meet increased performance requirements using limited resources (budget, materials, staff, and buildings). Considerable efforts have been devoted recently to develop high education performance in Morocco. The purpose of this study is firstly to identify some of these efforts. Thereafter, we have presented a brief overview of lean thinking principles and their implementation approach on Moroccan engineering education improvement.

Keywords: Moroccan engineering education, performance, limited resources, lean thinking, implementation, approach, improvement

1. INTRODUCTION

Engineering education success is becoming a major driver of competitiveness in a knowledge-driven economy. Engineering graduates learn to apply scientific principles to develop product and process that contribute to promote sustainable development, national security, resource management, innovation technologies and economic growth. In this way Morocco has devoted special efforts to perform high education quality.

Engineering education system contains a set of processes that can be optimized in order to improve schools performance while saving costs and eliminating wastes.

Lean thinking is a manufacturing philosophy to reduce costs by eliminating non-value added activities. It is not only applied in manufacturing, but also can be applied in any kind of organization to achieve high performance levels. This paper presents lean principles, goals and benefits. It also describes the implementation approach of lean thinking in Moroccan engineering education.

2. MOROCCAN EFFORTS TO IMPROVE ENGINEERING EDUCATION QUALITY

Higher education is a key lever for development, particularly in a knowledge economy relying on research and innovation. In the light of the new expanded vision of the Moroccan educational reform (2015-2030), the efforts go towards enabling all higher education institutions to follow the strategic objectives of the National Education and Training Charter. Strategic actions in terms of higher education and scientific research contain a number of key aspects that we summarized as below [1]:

- Training and recruitment of 15.000 teachers-researchers in the horizon 2030
- Gradual increase in the GDP (Gross National Product) allocated to scientific research funding to achieve 1% in the short term, 1,5% in 2025 et 2% in 2030
- Development of orientation and guidance systems in Moroccan higher education institutions
- Diversification of the language choices provided by higher education programs

In order to achieve these objectives, Moroccan government dedicates a budget especially to fund higher education improvement projects.

In the 2015-2016 academic year, 4% of the state budget was allocated for high education financing as we have illustrated in Figure 1. It includes operating budget (staff pay, scholarships, subsidies to university residence, subsidies to university institutions, promotion of scientific research, administration) and investments. Institutions of engineering education represent 13% of the total number of university establishments of higher education [2].

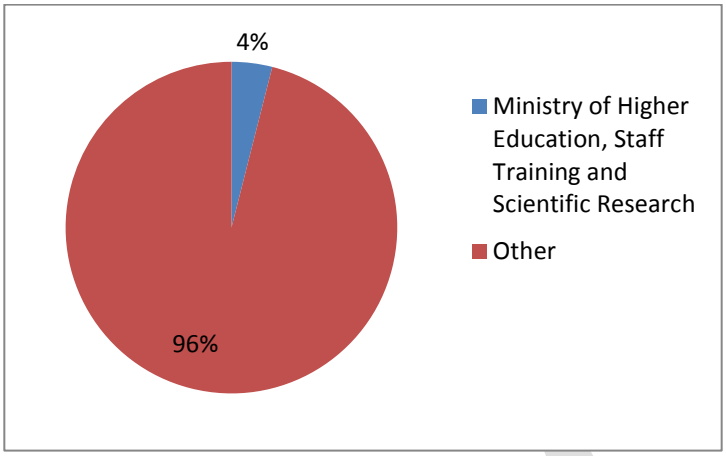

Figure 1. Distribution of Moroccan budget in 2015-2016

3. CONSTRAINTS OF MOROCCAN ENGINEERING EDUCATION DEVELOPMENT

In Morocco, the improvement of quality of engineering education is being hindered by some factors, such as:
-**Massification**: Moroccan engineering institutions produce a growing number of engineers looking for professional insertion. For example, the number of students studying engineering at academic institutions has increased by 7,80 percent between 2014-2015 and 2015-2016 (17 284 in 2014-2015 and 18 633 in 2015-2016) [2]. In order to deal with the situation of massification, institutions of engineering education have to develop the adequate strategies and resources (human, financial, material) to ensure equity and improving quality across education systems [3].
-**Market demand**: The accelerating pace of socio-economic disruption is changing the skills required by employers. Education systems are concerned with identifying skills that are needed today and anticipating those that will become so in the future to enable engineers to seize emerging opportunities [4].
-**Limited resources**: financial, human and physical resources are limited, these resources should best be distributed, managed and exploited to promote continuous improvement in education [4].
-**Competitiveness**: there are almost 35 institutions of engineering education with almost 135 engineering field in Morocco, in addition to private engineering schools that provide a competitive engineering training [5]. When it comes to employment, engineers of both government and private institutions with the right skills needed in the labour market can easily seize opportunities. In a context of heightened competition, innovative engineering schools must offer the widest choice of engineering degree programs that can enable engineers to be adaptable and operational on their job.

4. CHALLENGE OF DOING MORE WITH LESS IN THE LEAN THINKING

Moroccan country is in a situation of economic difficulties which strongly affects the resources allocated to different development sectors and at the same time performance is necessary to stimulate economic growth. As a result, engineering education institutions are expected to promote high quality (doing more) while using the minimum amount of resources (human effort, time, space, equipment, and budget). To be more efficient, engineering institutions need to be able to identify, reduce and eliminate waste in the learning process [6]. The challenge of doing more with less has been called "Lean" by scientists at Massachusetts Institute of Technology (MIT).

4.1 LEAN THINKING GOALS

Lean originated in the mass production setting in the automotive sector, specifically the Toyota Production System. The lean approach has then been adopted in every process different from that of high volume repetitive manufacturing such as healthcare, administration and higher education. Lean, simply defined, is an approach of eliminating waste from the process and maintaining continuous improvement [7]. The important goals of lean systems can be described as follows [8]:

- **Quality improvement**: to gain a competitive advantage, a company must focus on the customer satisfaction and be always confident that the product delivered meets the customer's need
- **Waste elimination**: waste is described in the lean context as any step within the process that doesn't participate directly in achieving the desired process output
- **Time reduction**: the most important way to reduce time in the process consists on waste elimination
- **Costs reduction**: in order to reduce costs, a company must produce without non-value added activities and only to customer order

4.2 LEAN THINKING PRINCIPLES

James P. Womack and Daniel T. Jones defined lean in their book Lean thinking as "Lean Thinking can be summarized in five principles: precisely specify value by specific product, identify the value stream for each product, make value flow without interruptions, let the customer pull value from the producer, and pursue perfection". Lean is based on five fundamentals value, value stream, flow, pull and perfection [9]. We can define the latter as follows:

Value: value is defined from the customer's standpoint. It determines what the customer specially wants and will pay for. Value is about meeting the customer's demand at a given price at a given point in time. Any characteristics in the product that do not provide value to the customer are undesired.

Value stream: a value stream consists of all the processes, steps, and materials required to produce and deliver the end product or service

Flow: once the value stream is defined, the elimination of waste is an important component of achieving flow, which is reached when the process progresses through a series of value-added steps. The elimination of wasted activities will result in the fact of saving time and delivering the product or service to the consumer more quickly.

Pull: it means that the process responds to customer pull and doesn't produce anything until the customer orders it

Perfection: it refers to the process of producing without waste, using a continuous flow and according to the customer demand. Lean is not about a static effort and vigilance to perfect, it requires continuous improvement of each and every aspect of the process.

4.3 LEAN THINKING IN HIGHER EDUCATION

Lean Higher Education (LHE) refers to the implementation of lean thinking in higher education. It has been successfully adopted by many universities to respond to higher education's heightened expectations, emphasize respect for people and continuous improvement. Some of these universities that have applied lean thinking to improve their administrative processes and academic processes include [10], [11]:

- University of Central Oklahoma (USA)
- University of Aberdeen (Scotland)
- University of Waterloo (Canada)
- University of St Andrews (United Kingdom)

4.4 LEAN HIGHER EDUCATION BENEFITS

Lean has been named as a successful approach to improve customer satisfaction by eliminating wastes and improving flow in many higher education institutions [11]. We have described in table 1 some of the positive and promising benefits of implementing lean at three universities in the United States.

Table 1. Lean higher education benefits

Rensselaer Polytechnic Institute	University of Central Oklahoma	University of Iowa
Formulate clear learning outcomes and objectives (define specific skills and knowledge to be achieved)	Decreased number of pieces of paper generated per work order by 88%	Decreased time of the employee hiring process by 33% (from initiation to job posting)
Use updated course materials (use emerging technology in learning, eliminate duplicate case studies across courses, show how course concepts will be applied in real business practice)	Decreased annual paper cost by 92%	Decreased number of the employee hiring process steps by 17%
Determine class level to establish course progress to improve flow and save time	Decreased average number of days to assign a work order by 90%	Decreased reworking submissions in the employee hiring process by 50%
Use different learning style to stimulate student participation and motivation	Increased percent of work orders submitted by e-mail from 26.8% to 91.1%	Reduced number of steps in the contract administration by 62%

Design Transparent Assignment to Enhance Student Success		Reduced waits for contracts administration by 65%
Make best use of students feedback and suggestions to improve current and future course design and delivery		Reduced review time for complex contracts by 16%
		Eliminated 20 days between the time from bid opening to contract execution

Process optimization and cost saving remains a key issue for universities of all sizes. By implementing a lean approach university can optimize its processes such as hiring process, contract management, planning, course design, and course delivery. Cost savings can be invested in financing strategic project. For example, purchase and install new equipment and technology to improve the quality of education.

5. LEAN THINKING AND MOROCCAN ENGINEERING EDUCATION

5.1 MOROCCAN EXPERIENCE IN LEAN MANUFACTURING

The Ministry of Industry, Commerce and New Technologies (MICNT) and the National Agency for the Promotion of Small and Medium Enterprises, have launched the INMAA initiative (the Moroccan improvement initiative) in 2011, in partnership with the McKinsey & Company consulting firm. The purpose of this initiative is to encourage operational transformation of 100 enterprises per year, this transformation falls within the context of industrial emergency plan. INMAA help companies to implement lean principles and achieve sustainable performance improvement by recording an increase in productivity of 25%, a decrease in unit costs of 20% and a reduction in production deadlines of 50%. Many companies have adopted the lean approach to build their own production system, such as Renault Production System (RPS-Renault), Valeo Production System (VPs-Valeo), Delphi Manufacturing System (DMS-Delphi) and Danone Manufacturing Way (DaMaWay) [12], [13], [14].

5.2 MOROCCAN ENGINEERING EDUCATION PROCESS

Engineering education refers to the set of processes engaged in providing students with the necessary skills and knowledge to achieve employability in knowledge-based societies. In a context of limited resources and increased requirements, Moroccan engineering schools must seek strategies to promote performance improvement and operational excellence [15]. In table 2, we have identified some of engineering education processes.

Table 2. Engineering education processes

Phase	Processes
Planning	Identifying learner needs (employability skills and abilities)
	Setting achievable objectives to meet the learner needs
	Identifying the teaching content and strategies
	Resources planning (teachers, employers, available materials, time, budget)
Implementation	Reserving a classroom
	Offering courses
	Advising students
	Establishing a partnership with an external institution
	Performing education using specific tools and strategies
	Providing medical or mental health services
Evaluation	Verifying the achievement of the objectives
	Evaluating student's knowledge

Engineering education is a system that creates value for its customers. We can identify two sets of customers external and internal.

Some of external customers are the services industries, manufacturing industries and government agencies that create job opportunities for engineers. The engineering education's internal customers include students, teachers, administration staff, and directors. All these beneficiaries should work together to achieve continuous improvement. Moroccan engineering schools should work hard to attract the best students that are the most important internal customers. If the engineering school doesn't increase stakeholder satisfaction, the customers will seek their needs in the other competitive schools:

- Best student can enroll in another school
- school members can be recruited by other schools
- Companies can recruit engineers trained elsewhere
- Donors can support any other competitive school

5.3 IMPLEMENTATION OF LEAN THINKING IN MOROCCAN ENGINEERING EDUCATION

Lean will enable engineering education staff perform its work and increase its feeling of fulfillment and motivation. It offers the methodologies and the tools to achieve strategic objectives, engaging all stakeholders in higher education. Lean offers a set of transformations that affects many aspects of an engineering school simultaneously, helping engineering schools to become more competitive and use their limited resources (staff, budget, materials, building) more effectively. Lean approach can help Moroccan engineering schools to reduce or eliminate process steps that don't add value to the customers (students, manufacturing companies, staff, and so on) in order to improve the flow of the process and relieve staff of unnecessary tasks. In this way, all stakeholders are engaged in achieving successful lean transformation. In table 3, we have identified some examples of engineering education wastes [11], [16].

Table 3. Engineering education wastes

Factors inherent to the process	Examples of wastes
Human resources	Goal misalignment (when stakeholders don't share the same goals)
	Waste of incorrect assignment (when staff members are assigned inappropriate tasks)
	Waste of waiting (when the process is stopped or slowed while waiting for ressources)
	Waste of non optimal processing (when task is performed in an ineffective way)
Process	Waste of ineffective control (when performance measurement doesn't have a long-term effect on the process performance)
	Waste of variability (when data is not updated)
	Waste of non-strategic effort (when effort is invested in tasks that don't satisfy long-term objectives)
	Waste of unreliable processes (when effort is invested in correcting the impact of ineffective tasks)
	Waste of non standardization (when work is not standardized)
	Waste of sub optimization (when process contains duplicative steps)
	Waste of poor scheduling(when process comprises uncoordinated activities)
	Waste of uneven flow (when additional resources are required to deal with unexpected demand)
	Waste of checking (when effort is invested in reviewing suspected steps)
	Waste of correcting errors
Information	Waste of information translation (when data can be modified by staff at different steps in the process)

	Waste of missing information (when process presents missing data)
	Waste of irrelevant information (when the process is overloaded with unnecessary information)
	Waste of inaccurate information (when effort is invested in correcting the results of using incorrect data)
Asset	Waste of overproduction and inventory (when process surpasses what is needed)
	Waste of unnecessary transport
	Waste of overburdening people (when tasks exceed individual capacity)

5.4 STEPS OF IMPLEMENTING LEAN ENGINEERING EDUCATION APPROACH

Lean approach is about engaging all stakeholders who are part of engineering education process to apply lean strategies and tools to achieve continuous improvement. Our study will be based on the different steps that we summarized in figure 2 [11].Teamwork organization is the key constraints to conduct a successful lean engineering education transformation. Creating an interdisciplinary team with highly skilled members who are collaboratively involved in achieving shared objectives is a vital tool for process improvement. The primary focus of a Lean transformation is the identification of customers and the development of a clear vision of what they want and expect from the process. If the university has a clear vision about its beneficiaries, it can easily meet their needs and expectations. Lean team members should work together in order to develop a deep understanding of the current process and identify all its steps and activities. These steps should be carefully reviewed to detect no value added activities and implement lean tools to eliminate wastes and improve flow. Lean steps and tools rely on the continuous improvement of processes.
The PDCA cycle is the most used methodology to implement a continuous improvement strategy in an organization. PDCA refers to the acronym "Plan, Do, Check, Act**"** known as the cycle of continuous improvement or Deming Cycle. It is an iterative four-step problem solving model to promote continuous improvement. This cycle is shown in figure 3.

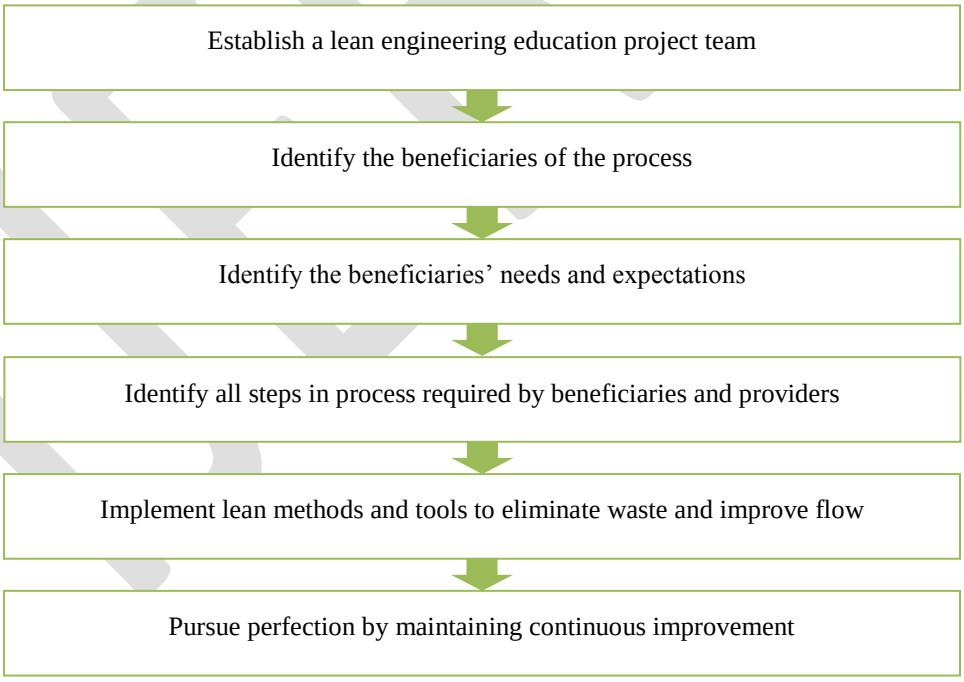

Figure . Steps to implement lean approach

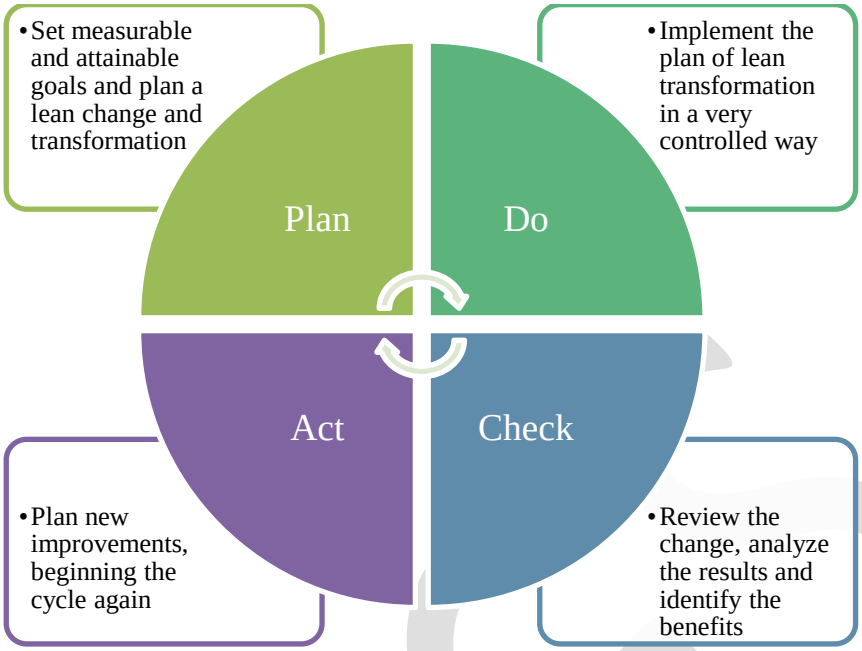

Figure 3. PDCA cycle

6. CONCLUSION

Through applying lean thinking in engineering education, Morocco can meet the challenge of doing more with less. This means, that engineering institutions will promote high performance using the available resources (human resources, financial resources, building, materials) to improve the quality of education. Lean thinking is a strategy built on continuous improvement and respect for people. Moroccan engineering institutions must take full advantage of the successful implementation of lean in many universities in the world. Engineering schools can benefit from applying lean thinking principles in terms of quality improvement, waste elimination, time reduction and costs reduction. In this paper we have deeply identified lean thinking principles, goals and several steps to be successfully implemented in Moroccan engineering education.

Through the case of the Higher National School of Electricity and Mechanics (ENSEM), we will determine how "lean" can be successfully introduced into Moroccan engineering schools while respecting the following steps:

- Establish a lean engineering education project team
- Specify the value desired by the beneficiaries
- Identify the value stream of the engineering education process
- Implement lean tools to eliminate wastes
- Stimulate continuous improvement strategies

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