

Chapter 2

Lean Education for Applied Science Universities: A Proposal by Federal Institutes of Applied Sciences in Brazil

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2.1 Introduction

“Lean” is the Womack et al. (1990) designation for the industrial process revolution proposed by Kiichiro Toyota for his father’s company—Toyota, after the Second World War. More than a collection of tools and methods, Lean is a philosophic approach that changes both the individual and the organizational culture taken by principles “continuous improvement” and “respect for people” to increase the value and performance of processes by elimination of waste tasks and improvement of its remaining.

Lean principles can be applied in many different areas like construction, coaching etc. Lean Education is an appliance of the philosophic approach (also Lean Thinking) in educational contexts intending to increase student performance and save costs by increasing the value and performance of school organizational processes.

Despite Brazilian government investments in Education, a lot needs to be done. From infrastructure to review of pedagogical methods. It is not an easy challenge: in a territorial comparison between Brazil and Finland, for instance, you can see that Brazil is 25 times larger. The exceptional territorial and population magnitude increases, significantly, the challenges of managing this young country (only 515 years old) of European colonization.

From the first industrial revolution processes, Brazilian education adopted the organization model and practices. Although not a Brazilian privilege, since public

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schools, on a global level, traditionally ground their practices and ways of thinking on the “factory model”, these disseminated models are not suited to the new demands of contemporary society.

As explained above, Brazil has a large territory and population—202,768,562 inhabitants in 2015 (IBGE 2015). In this context, the role of the network of Brazilian Institutes of Applied Science plays an important role in Brazilian education.

As detailed in Sects. 2.3.1 and 2.3.2, the roots of Brazilian Federal Institutes of Applied Science date back to 1909, consisting now of quite a large institutional network comprising of 341 campuses spread throughout the Brazilian territory.

Despite few exceptions, and considering the magnitude of the network of Institutes of Technology, empirical observation shows that the “factory model” is widely applied in management and pedagogical thinking. From this problem, it is possible to identify some driving questions such as: Is it possible to increase performance outcomes from an educational process as a whole? Is it possible to increase effectiveness and quality of the learning process of students? Is it possible to improve cost saving? Is it possible to increase customers and stakeholders satisfaction?

Lean appliance in Brazilian industries is very late. Until the 90s, it was not a reality in the industrial production context (Ferro 1992). In the educational area, it is not a reality as the “factory model” is still common sense. It is not possible, at this point, to address all the aspects involving such relevant issues, which justifies, therefore, the need for improvement.

Thus, the main goal of this study is to present a model to trigger the discussion about Lean Education under a pedagogical and managerial point of view, not only within the Brazilian network of Institutes of Applied Science, but also in other similar public educational systems. The study also presents a review of Lean and Lean Education concepts, as well as an overview of pedagogical models used at the Brazilian Institutes of Applied Science.

This chapter is structured in six sections. Section 2.2 gives a brief description of the historical evolution of Lean concepts. This is followed by a section on Lean in Education. Section 2.3 brings an overview of the development of Brazilian vocational education, specially the creation of the Federal Institutes of Applied Science, and their pedagogical and administrative infrastructure. Section 2.4 presents the model of Lean Education proposed for implementation at the Federal Institutes of Applied Science, which may be a starting model to similar cases in Brazil, or in other countries. Section 2.5 brings some outcomes from the presented model, and references are given in the last section.

2.2 About Lean

After World War II, Japan was a war-torn country with economic, financial and social development needs. For this reason, the Japanese government promoted a series of visits to American companies trying to apprehend their industrial models, and apply them in Japan to boost their economic and industrial development.

In this context, a young engineer and entrepreneur named Kiichiro Toyoda had contacted the famous American industrialist Henry Ford who showed him his enormous and complex automotive industrial process. From this experience Toyoda noticed that the American industrial process could not be applied in the Japanese context, since Japan did not have the same amount of resources as the United States.

The social and economic context in Japan was different from the United States: while the industrialization process and urban life were a reality in the United States, Japan was a rural country. The United States had plenty of resources and avid urban consumers with general needs. On the other hand, Japan was a country with very limited production resources and rural consumers with specific needs. Therefore, the challenge for the Japanese development was to create a model adapted to the existing reality of scarcity in which do more with less, have continuous improvement and respect for individuals, would be a kind of mantra. In this context, “less” means not only few resources (human, material etc.) but little effort, compared with the American industrial model (Womack et al. 1990).

With such challenges, Toyoda developed a production process model based on four premises: (1) Long-term thinking philosophy; (2) Waste elimination by continuous process improvement; (3) People and partners respect and grow; (4) Continuous improvement and learning by a problem-solving approach (Liker 2003). These basic premises has driven the production style proposed by Toyoda, allowing Japan to change the global industrial production model after the 70s. According to Alves et al. (2014, p. 1), “This learning system inside company doors has been the Toyota success and inspiration for many manufacturing industries and services providers to follow”.

Because of the petrol crisis, the United States was under a restrictive economic situation in the late 70s. The high prices of oil made American automobiles and their industrial production model unsuited for the new reality. The huge and guzzling cars produced on assembly lines based on the outdated concepts of Henry Ford, in which the waste production was constant and the employee was a mere operating machine, no longer accounted for the current reality. Thus, the American government focused on the Japanese production model developed by Toyoda, hoping it could solve their problems.

In this scenario, Womack and colleagues, MIT researchers, made a series of studies that adapted the Toyota model to the western management philosophy which they named Lean (Alves et al. 2014). According The National Institute of Standards and Technology (NIST, s.d.), Lean is “... a series of tools and techniques for managing (...) organization’s processes. Specifically, (...) focuses on eliminating all non-value-added activities and waste from processes.”

To apply the principles of Lean, Womack et al. (1990) developed a methodological process to improve the productive process of manufacturing, eliminating seven different wastes by following five steps along the industrial production process.

- **Over processing**—is any demand of tasks, activities existing at the production process that are not really useful to aggregate value perceived by the customer in the final product. For this reason, this idle process is considered as waste, since all effort and resources applied will not be useful to the final result and perceived as quality by the customer.
- **Overproduction**—is caused by a production faster or larger than necessary (demanded by customers), resulting in problems like large batch sizes, unreliable process, production and market/customer demand mismatch. Contributing to increasing inventories of final products and processing products, is a kind of waste since these waiting products mean investment of production resources (material, people etc.) that do not aggregate value to customers and the organization.
- **Inventory**—Promoting huge product stock of manufactured or in process products. It is a consequence of Ford's way of thinking. Focused on a homogeneous market, this concept is a trap to contemporary production needs since it hides many bad contingencies that exemplify waste of resources like unidentified defective machines manufacturing defective products; unnecessary human workload and unnecessary use of production resources.
- **Transport**—Within the Lean context, this kind of waste refers to any kind of unnecessary and useless movement of raw materials, products, production equipment etc., resulting from inadequate layout of the workstation, bad work flow, poor layout with extended gaps between operational steps, multiple and redundant stocks. All these are examples of waste cause.
- **Motion**—Refers to all the unnecessary motion of human parts or machines within a process. It can result from an inadequate step-by-step workload plan or an inadequate building layout or equipment arrangement.
- **Waiting**—is any idle time produced when interdependent processes are not synchronized, generating human or machine waiting, or slowing the process in its whole.
- **Defects**—is a quality error that increases final costs more than expected, because of the need of defective items to be reworked or replaced is a waste of resource and materials.

Waste elimination is a priority in lean application, and five steps can be followed to achieve it (Womack et al. 1990):

- **Specifying value**—Value can be understood as what is perceived as really important by the customer. It is not the organization but the customer who defines what is valuable. A usual mistake at this point happens when the organization is sure it knows what is really important for customers without previous enquiry.
- **Mapping value stream**—Once the customer's concept of value is defined, it is important at this step to analyse the value chain in its whole, and categorize the process in three categories: (1) the ones that really aggregate value; (2) the ones that do not aggregate value but cannot be eliminated at first since they contribute

to the maintenance of process and of quality and; (3) the ones that do not aggregate value and need to be eliminated immediately. In its chain value analysis, the organization usually focuses only on short-term indicators, i.e., being more concerned about costs than value.

- **Flowing the processes**—This is the most difficult and stimulating stage, since it presupposes changing the mind of those involved in the process. From a philosophical perspective, it is like shifting from the Cartesian (Descartes 1637) way of thinking to the Complex (Morin 2001) way of thinking. The adoption of a Systemic approach (Bertalanffy 1968; Uébe Mansur et al. 2013) helps this change of mind process since it extrapolates the initial idea of process segmented in departments and sections as recommended by Ford and Taylor.
- **Pulling the processes**—Once the processes are flowing, it is necessary to reverse them, making the customer call for the production. This concept production originally occurring at push conception will happen under a pull conception. This process is important in the way to eliminate a lot of wastes like inventory, transport and others since the production will start and be produced after customers ask for it.
- **Promoting perfection**—The main goal of this step came from the idea that Lean application needs to be a continuous improvement, as there is no end in the process of reducing wastes and since customers' need and behavior change all the time in regards to what is valuable for them.

Until the 90s, Lean was not a reality in Brazilian industrial production. This was mostly due to two main aspects: working models and human resource policies.

Several issues contributed to effective adoption of Lean Effective in the 90s, including: previous success of mass production model since the 50s; adoption of Lean techniques not regarded as a behavior philosophy; lack of dialogue among employers, workers and unions; centralisation of management authority; lack of pay-for-performance (Ferro 1992).

As a methodology for improving production processes in industries, Lean has been very successful worldwide and, as a result, its premises have been applied in different fields such as services, offices, higher education, construction, education, coaching and so forth (Colombo et al. 2014). For this study, the authors focus on an application of Lean—Lean Education (LE).

2.2.1 *Lean in Education*

Education is a term used to refer to the process of providing the development of knowledge, skills and reasoning in a student or student community (Ziskovsky and Ziskovsky 2007).

Lean Education (LE) is the Lean principle applied to Education with the intention of boosting student performance and saving costs. According to Ziskovsky and Ziskovsky (2007, p. 12), the goal of LE is to "...allow educators to

perform the work they went into education to do” by “...a common vision and clear goals that everyone both owns and understands”. Some questions can guide this path: What things keep you from doing your work? What should you not continue doing? What makes your work easier, satisfying, and successful? What would improve the skills and capabilities of your collaborators? What would improve your work environment?

LE does not mean shortage of resources. The most adequate idea for LE would be “Doing more with enough”, i.e., eliminating steps not valued by customers, since the focus for each step is the aggregation of value by respecting people and recognizing the importance of each process to the mission of the organization.

Taylor and Ford’s “factory model” has traditionally been adopted in public schools grounded on Cartesian routines and ways of thinking. Adoption of this scientific management model results in process wastes that reduce efficiency (Flumerfelt 2008). Schools structured around quantitative variables such as amount of time spent on learning tasks, length of the school year, and amount of time teachers spend on instruction are examples of this ineffective way of thinking (Sizer 1984).

LE shows a useful way to change this disadvantage context, because Lean is not only an application tool, method, strategy or a set of improvement process steps, but a kind of map to a journey of learning by an organizations (Flumerfelt 2008).

Flumerfelt (2008) highlights some issues concerning bad results from LE application that come from an intent to use LE not as a philosophy but as a tool without promoting an organizational Lean culture. In this case, problems like inadequate budget prediction, ineffective remediation, and lack of developmental learning opportunities for students can result in Lean failure results.

2.3 Evolution of Brazilian Vocational Education

This section provides a brief overview of how education evolved in Brazil. Following a summary of how instruction was delivered during the colonial and monarchy periods, we present the sequence of reforms that paved the way to the current institutes of technology.

In colonial Brazil, education was mostly provided by the Jesuits who, following their goal of evangelizing non-catholic populations worldwide, opened missions and schools throughout the country. To facilitate the understanding of religious texts and participation in rituals, the Jesuits focused on the teaching of writing, reading and basic calculus (Xavier et al. 1994).

The moving of the Portuguese Court to Brazil in 1808 shifted the political status of the colony, bringing along an increase in various economic areas. This required the opening of the first vocational courses oriented to prepare technicians to work in Agriculture and in the incipient industry of the period. Several institutions, including military academies, were opened to boost studies in Arts, Science, Law and Medicine. Nevertheless, the disregard of the State to implement general

instruction nationwide contributed to increase exclusive opportunities for the more privileged classes.

The last decade of the First Republic (also Old Republic 1880–1930) was the period in which the traditional economic model based on the production and export of crops was gradually confronted by the need to increase and improve industrialization to supply missing products not available from European markets during or shortly after World War I. Along with the growth of the middle class, other factors such as the strengthening of leftist political groups (inspired by similar activities in Europe), and various modern literary and art movements, led to more demands for educational reforms.

One initiative was, indeed, successful in the long run, as explained next.

2.3.1 From Schools of Apprentice Crafters to Institutes of Applied Sciences

President Nilo Peçanha created, in 1909, the first public vocational schools—the so-called “Escolas de Aprendizes e Artífices” (EAAs)—one unit in each state capital, and the origin of the future federal network of vocational schools. The motivation for such action was the growth of the urban population in Brazil which, in turn, resulted in larger working classes who required better professional qualification.

Two proposals for educational reforms emerged in the following decades, especially in the early years of the Vargas administration (1930–1954): (1) the Brazilian Association of Educators considered education an essential instrument for social reforms and construction of a national identity; (2) the New School movement (also Progressive School), inspired by the principles of John Dewey and Adolphe Ferrière, claimed that schools should follow the rationale of factories to meet the demands of the increasingly industrial and urban society. The New School ideas also matched the principles of Taylorism (also Scientific Management). This meant adapting industrial means of production to schools; instead of one workshop in which the apprentice learned all the manufacturing steps of a certain component, the learning compound was organized in “sections” made up of various workshops. Gomes (2003) explains that the student would attend the various workshops, but become an expert in only one.

Significant changes in the Brazilian society of the period, added to the development model based on industrialization, strongly affected educational programs. The main concern of the Vargas administration was to train labour forces quickly and objectively to work in the new industrial compounds. Thus, the former EAAs became “Industrial Lyceums” in 1937, and later renamed “Industrial and Technical Schools” in 1937. This reform allowed students who finished vocational schools to apply to Higher Education institutions. According to Machado (2011), the Vargas’ educational policy “legitimized separation between manual and intellectual work”

by offering more structured secondary instruction programs to meet the aspirations of the leading social elites, while leaving vocational studies for the less privileged.

Following President Kubistchek's plan of economic growth (1956–1961), the "Industrial and Technical Schools" became "Technical Federal Schools" (Escolas Técnicas Federais/ETFs). A significant landmark in the 1960s was the implementation of Law 4.024 in 1961, which established the national educational guidelines (LNDBE¹). Machado's understanding (2011) is that this document met the demands of the national modernization goals, but encouraged, on the other hand, the increase of vocational evening courses of questionable quality.

Another proposal made after the military coup in 1964 aimed at "fast and constant recycling of the working forces" in the light of changes in various areas worldwide, and based, as well, on the principles of the Human Capital Theory.² This led to financial and technical assistance from foreign agencies, known as the MEC/USAID agreements. Despite the intentions of improving education within the government plan to boost economic development in Brazil, Machado (2011, p. 230) emphasizes the increase of: (1) private institutions to supply for the lack of public schools; (2) concern with preparing technocrat-bureaucrats; (3) ideological control of educational programs by associating education with the productive and capitalist demands of multinational companies; (4) decentralization of educational programs by transferring management of basic instruction to the municipalities.

This scenario remained quite the same for the next several decades including the civil democratic administrations as of 1991. However, several important factors contributed to economic and social changes: globalization and the emergence of digital technologies. In 1994, Law 8.984 integrated all federal educational institutions into the National System of Technological Education, reshaping the former ETFs into Federal Centres of Technological Education (CEFETs). Even though this reform was opposite to the previous neo-liberal educational policies, as it sought to expand public vocational schools, it failed to prevent the growth of private institutions who offered more qualified instruction to those wishing to enter a university. (Brasil/MEC/INEP 2010).

By federal decree in 2008, this pool of federal schools gained new status as Federal Institutes of Education, Science and Technology (IFs). Currently, there are 38 IFs with 341 campuses spread throughout the Brazilian territory, offering courses at various levels, including post-graduation. This educational network also comprises 02 CEFETs, Colégio Pedro II,³ and a technological university.

The underlying learning design of the IFs is that vocational studies become increasingly closer to more holistic educational curricula, i.e., that they provide both specific and general knowledge. Another goal is the offer of programs designed in accordance with regional productive arrangements in order to avoid migration of

¹Lei das Diretrizes e Bases da Educação Nacional.

²For further understanding, see: "Human Capital Theory and Education. Fitzsimons (1999)".

³Located in the city of Rio de Janeiro, this school is the third oldest educational institution in the country.

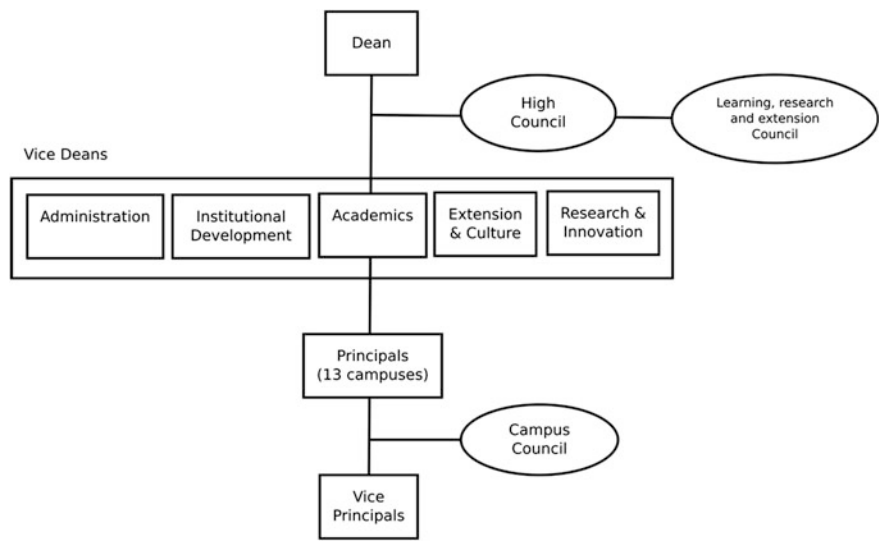


Fig. 2.1 Organizational chart of IFFluminense (IFFluminense 2016a)

local students. Tavares (2012) explains that while Brazilian education was largely influenced by the neo-liberal policies of the late 20th century, the current stage shows a more “democratic-popular” nature. One of the major features of the IFs is the offer of a vertical pedagogical structure in order to include historically marginalized individuals, and the development of critically-thinking citizens instead of the mere training of workforces.

2.3.2 Instituto Federal Fluminense: Structure and Mission

To illustrate the range of operation and the organizational complexity of the IFs, this part of the study presents the Instituto Federal Fluminense (IFFluminense).⁴ IFFluminense is a large institution located in the northern part of the State of Rio de Janeiro. The main sectors of its structure are presented in the followed chart (Fig. 2.1).

The following data in Tab. 2.1 provide an overview of Instituto Federal Fluminense.

The Institutional and Pedagogic Project drawn by IFFluminense in 2009 defines the philosophical and theoretical principles that guide its mission and academic actions. Some of the objectives listed in this document are:

⁴URL: www.iff.edu.br.

Table 2.1 Instituto Federal Fluminense in numbers (IFFluminense 2016a)

Campuses	13
Students	19,494
Teachers	913
Administrative Staff	744
Levels	High School; College; Post-Graduation; Adult Education

- Offer courses at various levels (High School, Higher Education, Post Graduation, Adult Education);
- integrate instruction, research and extension programs;
- acknowledge the student's contributions and experiences in the construction of knowledge;
- implement policies that foster social inclusion, access and permanence in the institution;
- enable dissemination and use of information and communication technologies as a tool for building citizenship;
- develop applied technological research to contribute to local and regional development;
- qualify and give due value to academic and administrative staff.

Academic and Administrative Structures at IFFluminense campus Campos-Centro

To best demonstrate how a campus is structured, we describe the administrative and academic organization of campus Campos-Centro (the oldest and largest unit of IFFluminense). The school principal is assisted by 12 directors (one for each school level, and/or specific support services) who, in turn, are supported by 47 coordinators (responsible for the various courses, areas of knowledge, and/or specific services such as the library, telecommunications, and various student support services).

Following the guidelines given by the Institutional and Pedagogical Project, Campos-Centro offers a wide range of academic programs as shown in Table 2.2.

As an institution devoted mostly to vocational programs, Campos-Centro provides the necessary facilities for empirical learning (workshops and computer labs, for example) which, in turn, require that teachers have good command of digital technologies. The 2014 Report issued by the New Media Consortium ratify the growing demand for pedagogical strategies such as personalized learning and/or other learner-centered approaches. This includes the use, for instance, of social media, virtual learning environments, and other information and communication technologies (ICTs).

A survey conducted in 2010 at IFFluminense campus Campos Centro shows that 90 % of teachers used some form of digital technology for elaborating class materials, but only 40 % actually used them in class activities. The survey also detected that one reason for this was the lack of adequate technological infrastructure in the classrooms. To increase and facilitate the use of ICTs in teaching and

Table 2.2 Courses offered at Campos-Centro (IFFluminense 2016b)

Level	Degree	Courses
High School (vocational)	Technician	Electro-Technology; Mechanics, Chemistry; Telecommunications; Labour Safety; Building Construction; Computer Science
College	Technologist	Industrial Maintenance and Electric Systems; Telecommunications; Systems Analysis; Graphic Design
	Bachelor	Automation and Control Engineering; Architecture and Urban Development; Information Systems; Science (Biology, Physics, Chemistry), Geography; Portuguese Language and Literature; Mathematics; Drama
Post-Graduation	Lato sensu	Environmental Education; Teaching in the 21st Century; Management, Design and Marketing; Management Information Systems
	Stricto sensu (Master's)	Environmental Engineering
Adult Education	Elementary to High School	PROEJA ^a

^aProgram that integrates basic and vocational instruction for students over 18 years of age

learning activities, the school implemented a special program—PTCE (Technology-Communication-Education Program) which led to several actions, including equipping classrooms with internet connection and various technological devices. Another significant move to foster the use of ICTs is the continuous incentive and support given to teachers to obtain qualification in the use of technologies. Despite these incentives, empirical observation by the authors show that most pedagogical activities are still carried out in more traditional formats.

2.4 Lean for Vocational Education in Applied Science Universities

The Lean Education model proposed in this study intends to bring Lean industrial concepts of wastes and improvement to vocational education in Applied Science Universities. Following this objective, we propose a model that takes into consideration the concept of wastes and its ensuing elimination steps adapted to the aforementioned educational reality.

- **Over Processing**—In education, it means any demand to students such as tasks, assessments, activities that are not really useful to the learning process. This situation usually occurs in teacher-centred learning approaches. Another situation that illustrates this issue happens when administration and academics promote overflow procedures for students as a result of the lack of rules and regulations.

- **Overproduction**—represents any knowledge acquired and assessed more than what is needed to the learning process. Traditional learning models overwhelm the student's mind with a lot of knowledge presuming it will be useful at some point of his/her professional life. Lesson preparation, application of assessments, application and correction of exercises can mean loss of energy useless for the needed knowledge. This learning approach usually generates unpleasant feelings in students who cannot understand the utility and applicability of a certain knowledge in their professional or personal life.
- **Inventory**—This waste is a consequence of Over processing since excess knowledge brought by over processed learning means a stocked knowledge in the student's mind, as student learning efficiency is proportional to absorption, maintenance and assessment capability. For this reason, it is necessary to identify what is actually waste and what is really meaningful to be maintained at the risk of maintaining obsolete knowledge.
- **Transport**—It refers to any kind of waste related to the process of knowledge exchange between students and teachers. Some examples of this waste are: bad teaching classroom methodologies, non-adoption of *multimediality*⁵ (in an excessive adoption of “brick and mortar” approach in comparison to insufficient adoption of multimedia resources), lack of accessibility to knowledge for students with special learning needs, non-flexible course structure and schedules can result in waste since it does not represent value for students or for the job market (waste from Over processing).
- **Motion**—In the Lean education context, represents all activities carried out by students, teachers and staff of an institution⁷, from class resources to classroom schedules, for instance. Waste examples are difficult in transit among university facilities (e.g.: distant campuses without adequate transport), bad accessibility for students with special locomotion needs. The synchronous-centred learning (face to face classes) approach without means to record and/or promote asynchronous class meetings. The adoption of a synchronous-centred approach promotes a linear, Cartesian and non-indexable knowledge motion framework. Student questions during class are usually lost, considering linear and non interruptible transport flow.
- **Waiting**—This waste occurs within the academic context, as some learning processes involve some sort of waiting by individuals. Lack of coordination among people and processes from inaccurate, inefficient or non-existent rules and regulations can bring bad results such as those. Some example are long-waiting lines students have to stand in the library, school registrars office, and even teachers late for class. Other examples are related to the lack of indexed knowledge like non-synchronised disciplines co-requirements.
- **Defects**—Knowledge is the most important product of a learning process. Wrong, inappropriate and obsolete knowledge acquired in learning process

⁵State of digital multimedia resources adoption.

means a waste by defective knowledge. Small batches of knowledge and its due assessments can avoid accumulation of knowledge defects by a just-in-time detecting problems approach.

Application of Lean Education (LE) is based on the five steps used in the implementation of Lean Thinking. It is interesting to highlight that, before any step, it is necessary to have a commitment vote from the managing staff for empowerment of leadership and team. Only after this, will it be possible to follow the Lean steps.

In the case of the Federal Institutes network, for each institute under the same Dean (since its structure provides a multi campus organization) it will be mandatory to define in which campuses the LE implementation will start. Each campus will have to establish a team to lead the first steps, and strong ties among team members are highly recommended. After these careful actions, it will be possible to follow the adapted implementation steps originally proposed by Womack et al. (1990):

- **Specifying value**—It does not make sense to think about quality in education if the institution does not know what is value in learning from the students' point of view. Since needs promotes value, the right thing to do is to identify the students' needs. Thus, it is very important that the student body trust institution managers. Students must perceive that the institution does not operate for its own benefit only, and meeting their demands is its sole reason for existence. For this reason, it is strongly recommended to include student participation in pedagogical planning meetings as a way to promote student-institution confidence.
- **Value stream mapping**—After identification of values in the learning process from the student's point of view, it is necessary to analyse each part of the learning process from a pedagogical and management perspective, and classify the process into the three categories: the ones that really aggregate value, the ones that do not aggregate value but are not possible to be eliminated at first as they contribute to the maintenance of the process and quality, and the ones that do not aggregate value and need to be immediately eliminated. From a pedagogical point of view, these actions illustrate the notion of value stream mapping: flexibilization of course curricula in order to eliminate, as much as possible, requirement disciplines; efforts to promote learning based on knowledge demand pulled by students, in which a learner-centred approach would be a significant contribution. From a management point of view, it is important to promote organizational streams and systems that facilitate the apprehension of what is really valuable by stakeholders as customers (students) and market companies (employers).
- **Flowing the processes**—In an educational context, the change of mind occurs in the pedagogical and management approaches. In the pedagogical approach, it is important to identify how to promote the values highlighted by students. Teacher-centred and "factory model" approaches are not recommended for this kind of change. For this reason, we need to think about how to promote interdisciplinarity, and more deeply, about how to eliminate knowledge stocked

in disciplines, promoting a just-in-time transit of knowledge in a student-centred approach. This means to reflect about how to promote ways to synchronise access to knowledge by students (not limiting knowledge access to the classroom, as it is usual in traditional teaching models), and how to promote knowledge at small batches (including assessments) in order to promote a more accurate student feedback of their learning feelings and confidence (decreasing the risk of idle knowledge inventory, for instance). A practical illustration of how it can be done is Khan Academy, a learning project proposed by Salman Khan (SRI 2014), where small knowledge batches, just-in-time and non-synchronicity are key elements of this approach. At this stage, the team responsible to manage changes will experience more difficulties due to the need of dealing with issues related to organizational policies, such as decentralization and loss of hierarchical power by teachers and staff to promote student empowerment in and out of the classroom.

- **Pulling the processes**—It is necessary to motivate students to pursue knowledge by adopting learning methodologies like Project-Based-Learning and Problem-Solved-Learning that usually promote a pull learning approach. At management level, the challenge is trying to think under organizational systems in comparison to the original point of view of a departmental “factory model”.
- **Promoting perfection**—In educational contexts, perfection means developing confidence compromise to be an increasingly precious partner to students (customers) and the job market (as company employees or entrepreneurs), in addition to running processes with mastery by eliminating waste. The team responsible for implementing LE needs to be synchronized with the Federal Institutions academic and managerial commissions, in addition to the students and companies by continuous and endless upgrading meetings. The plans, tasks and conclusions need to be in convergence, since there is no sense in disconnected improvements. Satisfactory results such as good performance self-assessment of their learning confidence do not indicate the process should be interrupted.

2.5 Outcomes

As reported by Ferro (1992), the factory model approach in education is almost a common sense in public education. Despite some isolated cases, this scenario is no different in Brazil.

Lean Education (LE) seems to be an interesting way to promote a student-centered learning since this approach fits the student as a customer in the learning process, disrupting traditional learning approaches.

The present model is proposed as a philosophical basis to be implemented in the next years in pedagogical and management contexts. For this implementation, we

suggest a pilot project for a Federal Institute campus as of 2016, with the following initial outcomes expected with the application of the this methodological actions:

- Focus on the concerns of students and institutional partners (companies) during the definition of educational contents;
- Strong connection among students from different campuses;
- Student-centered learning approach as learning philosophy;
- Learning centered in knowledge via cross-disciplines; not via centered-disciplines;
- Learning centered in the development of student skills and capabilities;
- Assessments focused on skills and abilities; not on acquired content;
- Focus on process learning; not merely on final assessments;
- Elimination of eventual lack of teachers for specific disciplines;
- Closer relationships among students, faculty, companies and society.

This is a redesign that may generate effective results over time and deepening of methodology. Therefore, the purpose of this study is to give a kick start and not exhaust the issue, something that meets the philosophy of Lean continuous improvement.

The network of Federal Institutions of Applied Science in Brazil is enormous. Therefore, proposals for dealing with pedagogical approaches as management actions need to be planned and patiently developed. Starting with a pilot experiment might be an interesting way to implement LE in the Brazilian network of Institutes of Applied Science.

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