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An Impact of the Application of the Lean Concept to Improving Industrial Engineering Education

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Abstract: *This paper emphasizes the importance of applying the LEAN concept in higher education of Industrial Engineers. The purpose of this paper is to present some possibilities of applying the Lean concept as an aid to the industrial engineering sectors in universities to develop better Lean thinking and the application of Lean education in this field. The paper presents Lean approaches that contribute to the improvement of teaching curricula and teaching processes, such as Lean Learning, Lean Thinking and Lean approach to online distance learning. Also, the new modified 7P Lean concept was presented, modeled on the manufacturing Lean concept, where the advantages of Improving Industrial Engineering Education were highlighted. Each of these approaches offers practical solutions and suggestions to highly educated institutions for the improvement of traditional and existing processes, and raises the world of teachers for continuous needs for improvement, which is the essence of the Lean philosophy.*

Keywords: *Lean concept; Industrial engineering education; Lean learning; Lean thinking*

1. INTRODUCTION

Over the past few decades, industry underwent phenomenal and revolutionary changes. With tools and techniques such as Lean Manufacturing, Six Sigma, Total Quality Management, business process reengineering, and concurrent engineering, the manufacturing industry made radical changes in the way it conducted business [1]. Using Lean principles, many organizations, not just from the industry, have significantly improved their business results. The Lean concept is multidisciplinary integrated at several universities as part of educational programs, with special emphasis on the education of Industrial Engineers. The organizational environment of highly educational institutions has changed dramatically in recent years and requires constant change and user orientation. The application of the Lean concept in the education sector is a completely new approach to improving education. But in previous years, a large number of researchers began to deal with this topic, so as a result of research, many Lean methods emerged. Lean concepts have helped many educational institutions to increase the number of students enrolled in courses. Sunder [2] emphasized the importance in finding new and improved ways of teaching, redesigning institutional infrastructure, and processes in order to survive and compete in the educational environment.

Lean Higher Education (LHE) Balzer [3] has enabled post-secondary institutions to seek similar improvements in response to the demands of the higher education marketplace: exceeding the expectations of students, faculty and other constituents; reducing expenses in an age of rising costs and declining financial resources; meeting demands for public accountability in terms of efficiency and effectiveness; and, most importantly, strategically leveraging all available institutional resources to fulfill the educational, scholarship and outreach missions of higher education [3, 4, 5].

Building a programme of education that reflects and keeps pace with industrial practice is difficult. We often hear of a skills shortage in the software industry, and the gap between what people are taught in university and the "real world" [6].

Lean concept is an organizational development program that strengthens the work performance and job satisfaction of each individual in the education system and forces him to constantly improve. Lean's task is to add value to teaching processes by eliminating unnecessary activities that affect the efficiency of teaching. In order for these Lean approaches to be successfully implemented in highly educated institutions, mutual cooperation in the teacher-student relationship is necessary, as well as a lot of joint work. The requirements of the labor market and industrial companies also have a great influence on

the definition of the concept, for the needs of which, with the ultimate goal, future Industrial Engineers are educated.

2. APPLICATION OF LEAN CONCEPT IN EDUCATION OF INDUSTRIAL ENGINEERS

Compared to all other industrial disciplines, Industrial Engineering offers the widest opportunities in building and developing a career. Graduated engineers have opportunity to work in a variety of jobs, from production, through management, to maintenance and quality control, not limited to the manufacturing sector, but also to other related engineering fields. Years ago, Lean became an important topic in the curricula of almost all academic educational institutions of Industrial Engineering.

In order to become competitive on the labor market, it is necessary for Industrial Engineers to be well acquainted with the Lean principles, which enable them to acquire the necessary modern and efficient LEAN skills. The JELA student union for industrial engineering and management conducted a research on this topic [7], where, among other things, the role of the Lean concept in bringing students closer to the labor market was presented. In modern industry, there is a constant need for mutual harmonization of acquired university knowledge of students with the needs of industry. Thus, it is necessary to develop numerous professional competencies during studies and their thorough application in practice. The approaches used in the Lean instruction have been carefully examined leading to a number of relevant findings, including end-customer identification and value-added competence development activities, as well as a number of strategies that promote continuous improvement and enable withdrawal and equalization of competence development [8].

2.1. Lean Learning approach in the education of industrial engineers

Lean Learning is a process of learning and development in order to achieve a high level of education in a quality and efficient way, in a timely manner and in the right amount, with a constant striving for change and waste minimization. Lean Learning aims to develop an innovative program for engineers on the Lean concept, as a successfully applicable alternative to current traditional methods in courses. Lean Learning is a process of learning and development in order to achieve a high level of education in a quality and efficient way with a constant striving for change and waste minimization. This efficient process emphasizes the comparative ratio of inputs or outputs (input-output ratio), viewing them as a return on investment and learning.

Lean Engineering learning should be compulsory on engineering curricula, and, particularly, on the Industrial Engineering field. Prior to the integration on the Industrial Engineering curriculum, Lean Engineering was already implemented by many organizations and, often, fostered by consulting companies. For this reason, if engineering students were taught about Lean Engineering, they would be better prepared to assume a leadership role in their organizations and/or to better communicate with Lean consultants [9].

This approach is based on the Lean approach used in Lean manufacturing in industrial systems. Educational institutions that want to move to the process of lean learning, when educating future industrial engineers, must work on the following 3S concept:

- **Support of team working on continuous development and training, including research**. First, all complicated and insufficiently reasonable activities, which are imposed on students, must be eliminated. Such as bulky equipment, travel from one classroom to another, workload with teaching materials, complicated tasks, requirements for faster learning than usual, etc. Overload during education can lead to student fatigue, which further implies underutilization of student potential. All of the above reasons can lead to certain variations, so management is suggested to eliminate the shortcomings in order to increase the performance of the process.
- **Simplification of curricula**. Curriculum updates are made systematically or over the years of individual updates made by faculty members [5]. Emiliani in his research expressed certain opinions that the curriculum should be constantly developed and improved [10, 11]. Program managers must eliminate shortcomings during the training, starting from the schedule of subjects, to the coordination of the dates of lectures and exercises, in order to avoid unnecessary waiting. This approach is based on smooth flow and aims to eliminate variations and unnecessary waiting caused by the schedule. Therefore, it is necessary to clearly and concisely define all the steps within the curriculum and ensure smooth and efficient work, using various techniques. Fliedner & Mathieson [12] conducted surveys in their research that suggest several implications for curriculum design for undergraduate and graduate business schools, lean education, and a broader systemic approach to vocational education.
- **Simplification of the teaching process and assessment process**. The teaching process and the assessment process certainly contribute to the education of Industrial Engineers. This approach requires greater engagement of educators and much more work and time, unlike the previous two, because it is

necessary to keep these processes under continuous supervision and control. It also requires a much greater experience of educators, as simplifying the teaching and assessment process is a very sensitive topic, and can very easily cause resentment among students. Emiliani, believes that the feedback, received from students in connection with the teaching process, is necessary to improve the concept of the course [13, 14]. Dei [15] in his paper claims that the acquired knowledge of graduates has significantly increased by improving and continuously updating the teaching process by applying the Lean concept, which has greatly contributed to increasing their value in the labor market. M. El-Sayed, J. El-Sayed, Morgan & Cameron [16] have demonstrated in their work how the Lean concept can improve assessment processes where "objectives, outcomes and performance criteria for all courses in the program should derive from and harmonize program-level specifications". To meet these challenges, realistic practical learning facilities closely resembling real-life scenarios that are able to provide effective and efficient backstopping to theoretical instruction are necessary - meaning that there should be minimal abstraction in teaching and learning methods [17].

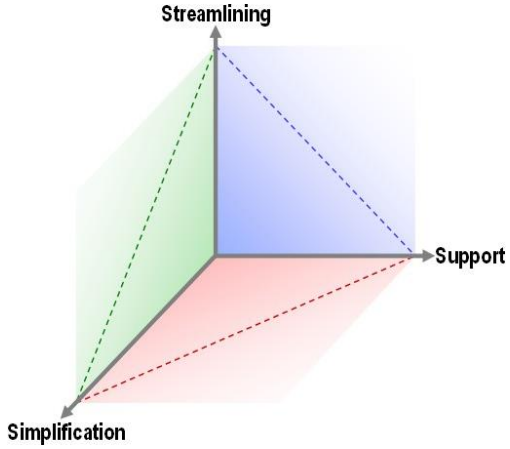

Figure 1. *Dimension of the 3S concept Lean learning approach [24]*

According to Veza, Gjeldum & Mladineo [18], Lean learning can be integrated not only into the education of Industrial Engineers, but also into the education of employees at all levels in the institution. Lean learnig shows that the Lean concept, can make a very big contribution to the improvement of the higher education process through an innovative learning experience during education.

2.2. Lean Thinking approach in the education of industrial engineers

Today, all large industrial companies require graduate Engineers to have the competencies to solve large and complex engineering problems. For this reason, it is very important that students recognize the importance and significance of their studies in a timely and appropriate manner. They do not initially see a direct link between the knowledge and skills acquired during their studies and what industrial companies require during their professional careers. These shortcomings can be corrected by applying different methods of learning lean thinking.

We can single out two very important factors when defining methods. First, at the same time we must work on the education and training of young Industrial Engineers, combining teaching and practice, and secondly, during the learning and training process, students must develop the most important skills and competencies required by the labor market, such as innovation, flexibility, creativity, entrepreneurship. etc.

Garay-Rondero, Rodríguez Calvo & Salinas-Navarro [19] in their research present a model of learning lean thinking that expands the availability of resources for training and development of professional skills in the field of Lean production. This model offers a number of very successful methods that can be applied when improving curricula and teaching processes, while improving and developing competencies in the field of Industrial Engineering.

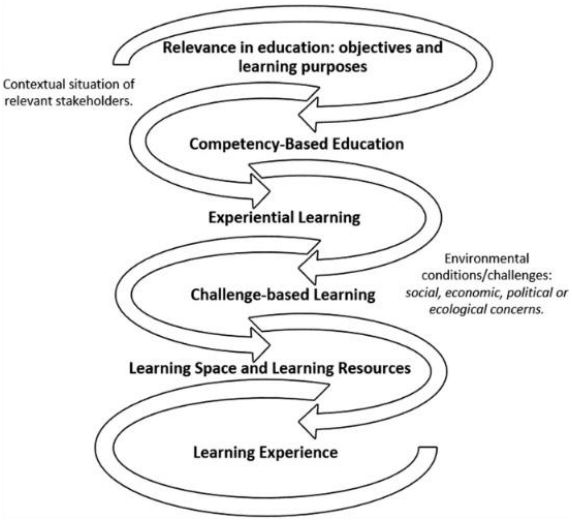

Figure 2. *Proposed model of learning lean thinking [19]*

The solutions offered by this model must be flexible in relation to the variability and transformation of primarily production processes. Frequent changes in product specifications, variable delivery times and unstable supply-demand ratios, etc. must be taken into account.

2.3. Lean approach to improving online distance learning

Distance learning has always been accepted with a certain amount of uncertainty and concern, both among teachers and students. There is a constant fear that this type of learning could reduce the

quality of education. Usually refers to the area of education that includes the redesign of teaching processes intended for students who are not able to physically attend classes in the classroom. Important influence on the implementation of this method of learning has the Internet and the application of information technology, which enable uninterrupted communication between teacher and student.

The contribution of this method of learning is reflected in the possibility of attending these courses, even for people with disabilities, people who are employed or busy with other obligations, people who are stationed in locations where these types of courses were not previously available. This method of teaching brings significant cost savings, both for the educational institution and for the students. Belanger & Jordan [20] in their book list certain advantages of applying online distance learning methods.

Table 1. *Expected benefits of Lean online distance learning* [20]

Learners	**Instructors**	**Institutions**
• Increased flexibility • Increased access to learning • Increased choice of institution • Lifelong learning • Access to remote experts • Increased performance • Increased promotion potential • Increased compensation • Better marketability	• Increased participation • Broader time frame to deliver courses	• Increased number of learners • Increased variety of learners • Competitive advantage • Decreased costs • More scheduling flexibility • Less classroom requirements • Increased employee satisfaction • Reduced turnover • Shorter training time

The importance of applying online distance learning is also reflected in the increase in student enrollment in such courses. Checking the effectiveness of the implementation of the online distance learning method can be done by conducting a survey or through a comparative analysis of the performance of each student after completing the course. Also, the goal of this learning method is to increase internal and organizational efficiency, then to encourage and empower teaching staff to improve previous teaching experience.

3. APPLICATION OF THE MODIFIED 7P LEAN CONCEPT IN THE EDUCATION OF INDUSTRIAL ENGINEERS

The Lean 7S concept, intended primarily for production processes, can also be used in Improving Industrial Engineering Education. The lean principles and practices used in industry can be successfully applied to improve the administrative teaching processes of higher education through an innovative approach to education. This paper will present a new modified concept based on Lean principles adapted to education. This modified concept is based on the following 7 principles (7P):

- **Waste elimination –** Educational institutions have an important task to use Lean techniques to eliminate waste in the form of shortages, in order to improve efficiency and efficiency in teaching. These performances, according to Maguad [21], Imply individual and organizational learning that takes place and then spreads throughout the organization. The first step in implementing this concept involves identifying and spotting flaws, and then eliminating them. All activities that do not affect the setting of results can be considered as waste, and as such they should be immediately eliminated from the program. The purpose of this principle is to point out unnecessary activities to educators and to keep them to a minimum, as much as possible.
  Practice has shown that the most common shortcomings that every higher education institution must eliminate: excessive bureaucracy, inconsistency of teaching materials with the planned curriculum, lack of coordination and mutual misunderstanding in the teacher-student relationship, inefficient use of all teaching aids, frequent overlapping of teaching contents, etc.
- **Enhance learning intensity –** This principle is reflected in the mutual harmonization of the requirements of industrial companies and the basic knowledge acquired during the studies. The acquired knowledge and skills provide students only with a starting point when looking for a job. During the implementation of this concept, both teachers and employers are required to make great efforts and joint cooperation in order for graduate students to acquire appropriate competencies.
  Practice has shown that attending the professional practice of students and going to large industrial systems during their studies gives the most effective results in improving learning. Also, this principle achieves that the most successful and most experienced employers from industry and economy can be included in the teaching process and thus contribute to additional education of students.

This type of cooperation requires a cumulative effect of education. This type of cooperation requires a cumulative effect of education.

- **Making the right and as soon as possible decisions –** Every decision-making process begins with identifying problems, gathering as much information as possible, generating alternatives, and ending with making a final decision. Making a decision on choosing an educational institution requires some caution, since students do not have the opportunity to test the chosen course. When making a decision, it is necessary to analyze all possible criteria, as well as the influence of many factors. The most common factors influencing the decision when choosing an educational institution for future students, based on many years of experience, are: the influence of the environment, especially family members and the environment, then the academic reputation of the institution, availability of teaching and non-teaching resources, location of institutions, tuition fees, curriculum, cooperation with industry and industry, etc.
  In practice, it has been shown that the most important criteria that students use when making a decision are those concerning a promising career and better advancement in employment. Students therefore see the possibility of career advancement as a priority in decision making, as well as whether they will continue their studies by attending master's or doctoral studies or not. This principle offers a range of activities that can be undertaken to help students make a decision as quickly as possible, such as: adequate marketing of the institution and its study programs, organizing "open days" where prospective students get acquainted with teaching and non-teaching resources offered by the institution, maintaining creative workshops, which would be organized in one day of the weekend and where direct cooperation between teachers and future students would be achieved, etc. Higher education institutions need to be aware of the influential forces that affect students when they enter this intricate decision-making process and gain an understanding of these variables if they are to meet the needs of students effectively [22].
- **Fast gaining of education –** This principle aims to provide students with the most efficient way to acquire knowledge and skills by attending Industrial Engineering courses. By applying this principle, higher education institutions have the opportunity to reduce the course program to the shortest and most comprehensive teaching units. This directly achieves more efficient learning and faster communication and cooperation between teachers and students. Unfortunately, practice has shown that a large number of teachers do not attach too much importance to the way students learn. Some of them still apply outdated methods of realization of teaching processes, which existed at the time of studies. However, the task of all teachers is to follow the fast pace of change in higher education and to adapt to it as quickly as possible.
  The purpose of this principle is to facilitate learning and to make it quality and efficient, continuously improving the curriculum and the teaching process and at the same time adapting it to the needs of students. After each lecture, the teacher must have an insight into the level of acquired knowledge and perform certain analyzes in order for the lecture to be successful. This principle also achieves flexibility in the way of learning, as well as in teaching, which can also be achieved by the method of distance learning. Teachers quickly receive feedback on the education of graduates, which gives them the opportunity to update and improve the teaching process for the next generation of students.
- **Continuous team empowerment –** This principle is based on the continuous strengthening of the educational team, which consists of teachers. The most important role is entrusted to the team leader, who is usually an experienced leader of the study program, and whose task is to gather around him teachers who are motivated and enthusiastic to improve teaching competencies in the field of Industrial Engineering. This team has the task to improve the efficiency of teaching processes, but also to motivate all other teachers to raise their teaching processes to a higher level. Team members should not be burdened with a list of specific tasks and responsibilities to fulfill, but should be encouraged to do their job as best they can. In this way, the awareness of all teachers is raised and over time an increasing number of them become part of the educational team. Teachers must also be able to maintain consistently high levels of performance to continually strive for better professional performance. It is necessary for them to improve using professional literature, analyzing periodical scientific publications, as well as by participating in expert and scientific conferences in the field of Industrial Engineering.
  Venkatraman [23] in his research lists the key areas that can be identified as a paradigm that everyone will adopt:

  1. Self-development to meet the requirement of the profession
  2. Self-study and reflection
  3. Training programmes
  4. Research and Development and Innovation

5. Collaborative Learning approach with the help of peer/experts/mentors

6. Awareness of Institutional, National and International goals of education

Increasingly frequent changes in higher education require continuous improvement and self-development of the educational team. This principle requires setting goals related to the development of teachers' competencies, continuous involvement in development activities and defining and delegating clearly defined tasks, as well as constant monitoring of progress. In practice, it has proven to be a very useful way for teachers to get feedback on which to determine which outcomes are most favorable.

- **Building integrity –** This principle refers to strengthening the integrity of higher education institutions and teaching processes. It came in response to, unfortunately, the increasingly inappropriate behavior of certain teachers and the abuse of their positions. Teachers and students as a whole must work together to build and strengthen integrity, establishing flexibility, sustainability, efficiency and responsiveness. To begin with, they must first examine their behavior and approach to education, and then compare them with traditional education and codes of ethics.
  Teachers have a key role in building the integrity of the teaching process, as well as in the ethical development of students. They must provide the conditions and resources to meet the goals, i.e. make educational and ethical preparation, which includes developing students' sense of ethics, encouraging students to think critically, establishing sincere awareness, strong character and developing ethical habits of behavior during education. This principle requires teachers to significantly increase the level of social responsibility in education and to find effective strategies and methods that will be based on basic ethical values. The ethical values that are most applicable in practice are highlighted:
  - Building moral values: to establish trust among students with exemplary behavior in all situations;
  - Building human values: establishing respect and honesty, both towards students and colleagues;
  - Building professional values: establishing a high level of excellence, efficiency and impartiality.
- **Perception of the whole –** This principle is reflected in the interaction of all the above principles, which is the task of all Lean methods, including this modified concept. The success of this 7P Lean concept directly depends on the interaction and coherence of all the above Lean principles. The implementation of this concept eliminates the shortcomings and achieves the division of the task into smaller units, which gives much better results and raises the quality of education.

Figure 3. *Phases of 7P Lean concept in the education of Industrial Engineers*

All participants in the process must have a good understanding of this modified concept of slimness in order to be successfully applied in practice. This concept also requires the interaction of all the above 7P Lean principles, and its success depends on the way the principles are implemented, the willingness of all participants to cooperate and the work environment.

4. CONCLUSION

The paper discusses how the application of the Lean concept can positively affect the improvement of teaching processes, especially in the field of industrial engineering. The paper presents a new modified 7P Lean concept in the education of industrial engineers. The possibilities of applying the Lean concept as an aid to the industrial engineering industry at universities for the development of better lean thinking and lean learning, as well as the application of the Lean concept in distance learning online are presented. 7 Lean principles were presented, as well as a series of practical solutions based on the experience gained during many years of teaching in the study program Engineering Management. Also, constructive proposals were offered to highly educated institutions in order to improve traditional and existing teaching processes. This modified 7P Lean concept is defined on the model of the Lean production concept, which aims to constantly improve and perfect the curriculum, as well as teaching processes, which is the essence of the Lean philosophy.

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