Chapter

Value Stream Mapping: A Method That Makes the Waste in the Process Visible

Nuri Ozgur Dogan and Burcu Simsek Yagli

Abstract

Defining customer and value in lean thinking is crucial. All wastes that do not add value to the customer in business processes should be eliminated. In the real world and related literature, there are various methods used to eliminate waste and improve processes. One of the methods frequently used is the value stream mapping (VSM). VSM is preferred since it enables to take the picture of a process. Moreover, VSM is the identification of all activities that create and/or do not create value in the processes, from the supplier of the product or service to the customer. This chapter deals with lean philosophy, lean techniques and specifically the VSM method. In addition, some examples of VSM applications in the service and production sectors are discussed and the findings obtained from these applications are evaluated. Finally, the chapter concludes with some managerial implications as well as potential future research areas.

Keywords: lean thinking, lean techniques, production and service sector, value stream mapping, waste

1. Introduction

Originating from Toyota production system (TPS), lean production (LP) or lean manufacturing (LM) has now become a well-known and widely adopted philosophy all over the world. Its first usages were limited with the production industry and therefore its initial applications emerged in the manufacturing businesses. As time passes, the service industry has begun to utilize from the LP philosophy and/or techniques. As the adaptation of lean expanded from production sector to service sector, its concept transformed from LP to lean thinking (LT).

Historical evolution of the "lean" started with TPS and continued as LP/LM, and finally became LT. No matter what anyone says, each of these terms indicates the same concept. Eliminating or at least minimizing the waste (Japanese: muda) in a system is the basic philosophy of lean and to produce the maximum output by using minimum resources is the main goal of it. Lean seeks for a system that tries to detract non-value added things from the processes and bring the value-added things into the forefront. These efforts become meaningful if the value is defined correctly and the system is designed and conducted truly. Value must be defined by the customer since he/she is the end user of the product and/or service. Thus, to give exactly what the customer wants, businesses must take into consideration the concepts of efficiency and quality. It is clear that an efficient and quality focused system uses the resources exactly as needed and produces products and/or services that satisfy the customers.

Many organizations from production or service sectors implement lean production as its main system or apply lean principles partially in its specific activities. These organizations utilize from LT with the aims of becoming more efficient, more competitive, and more quality oriented. Furthermore, in recent years LT spread from a single business to supply chains of multiple businesses. It is possible to say that LT attracts many businesses and these businesses want to transform into a lean business. Lean transformation process is an important inflection point for a business and it must be carefully initiated, designed and managed. The starting point of this transformation process is crucial and right method(s) must be used during the phase. Value stream mapping (VSM), one of the methods of LT, is the most suitable method that can be used in the first step. VSM is a paper and pencil based method that focuses on the current state of a process, makes all value and non-value added activities visible, and proposes a lean future state. VSM is dealt with in this chapter in a detailed way.

The rest of the chapter is organized as follows. Section 2 focuses on lean philosophy. Lean techniques are examined in Section 3, and VSM is explained in Section 4. In Section 5, there are VSM examples from the service and production sector for a better understanding of the subject. Finally, this chapter ends with discussion and conclusion.

2. Lean philosophy

Businesses should be recognized the importance of customer and value concepts. Customers do not want features that do not create value in products or services. All sectors, both product and service sector, should pay attention to this situation in order to compete with their competitors. This is because customers are not willing to pay extra for features that do not create value. Value can be categorized into three types: value added, non-value added and necessary non-value added operations [1]. Value added operations are processes that please the customer and must be in the process. Necessary non-value added operations are wasteful but necessary. Lastly, non-value added operations are completely wasteful and must be eliminated.

Lean philosophy is defined by Radnor et al. [2] as *"Lean as a management practice based on the philosophy of continuously improving processes by either increasing customer value or reducing non-value adding activities (muda), process variation (mura), and poor work conditions (muri)."* As can be seen from the definition, lean philosophy has emerged within the framework of some elements, especially waste (muda). Lean production is typically believed to be 7 types of waste [3]. These wastes are over production, waiting, transportation, over processing, inventory, unnecessary motions and defects (**Figure 1**).

The importance given to the service sector is increasing day by day. The lean production mentality continues to be implemented in the service sector. Lean philosophy, both production and service sector value, optimization, quality, standardization and simplification principles are common [4]. However, the wastes defined as 7 types in lean production are 10 types (**Figure 2**) in the service sector [5].

If the wastes are eliminated and the costs of waiting in stock are reduced, customer satisfaction and related sales will increase. Therefore, the purpose of both customers, employees and business partners will be achieved through the adoption of lean philosophy. On the other hand, in order to ensure continuous improvement, the wastes in the process must be converted to value. Furthermore, due to the rapid change in customer expectations, it is important to achieve perfection. Thus, Womack and Jones [6] proposed a *The 5 Steps Model* to help transform from value to perfection [7]. **Table 1** contains the 5 steps model and explanations of the expressions [6–11].

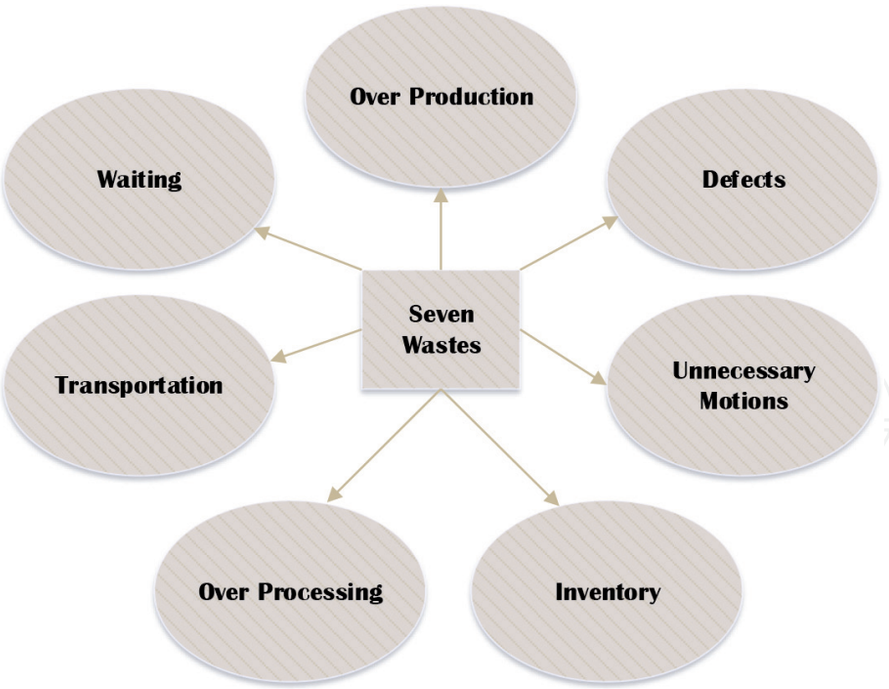

Figure 1.
Seven types of waste.

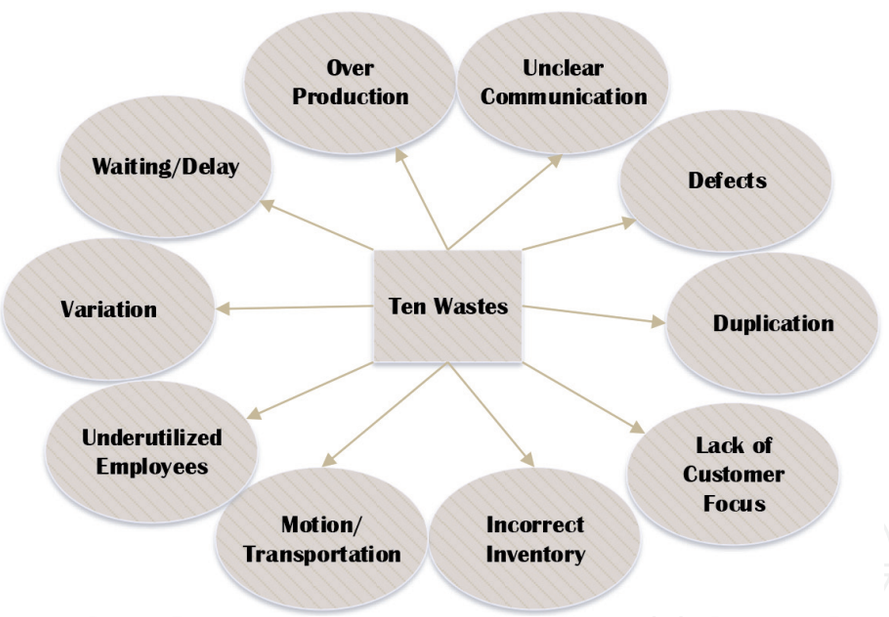

Figure 2.
Ten types of waste (service sector).

A number of lean methods are used in the realization of these steps (detailed descriptions in the next section). JIT and Kaizen, in particular, are the main philosophies in achieving continuous improvement and in reaching perfection [12]. Besides, lean philosophy has many benefits for businesses, employees and customers. These benefits are, reduced lead time, less rework, financial savings, increased process understanding, reduced inventory, less process waste, satisfied customer, standardized processes, improved knowledge management [3, 13].

There are some principles to apply the lean philosophy successfully in a organization [14]. It is a pyramid with 4P of lean way formed by the Liker's 4P of the Toyota way [15]. The 14 principles are represented by 4P [16]: philosophy, process, people and partner, problem solving (**Figure 3**).

The steps	Explanations
1. Value	Value is the source of the pleasure and needs of the customers who buy the product or service. It is the starting point of lean philosophy. It is necessary to understand the needs of the customers, to define the value correctly, and to implement this in all processes
2. Value stream	The value stream is all the activities needed during the generating of the product or service. These activities may be activities that add or do not add value to the product or service. Additionally, with all activities being seen, wastes that non-value adding will be recognized
3. Flow	Continuous flow can be achieved by detecting and eliminating the wastes in the process. Furthermore, it is necessary to implement this throughout the value chain to ensure full flow, not just one process
4. Pull	The pull system means that production or service will not be commenced without a customer approval. This is the exact opposite of the push system. Production will be tailored to the customer in this system. In addition, over production and unnecessary inventory are prevented by JIT applications
5. Perfection	Perfection is the last step that separates value and waste. This step regulates the flow, ensures the continuity of the flow and initiates the pull system. Perfection is maintained by continuous improvement. Perfection means that lean thinking is adopted and implemented

Table 1.
The 5 steps model.

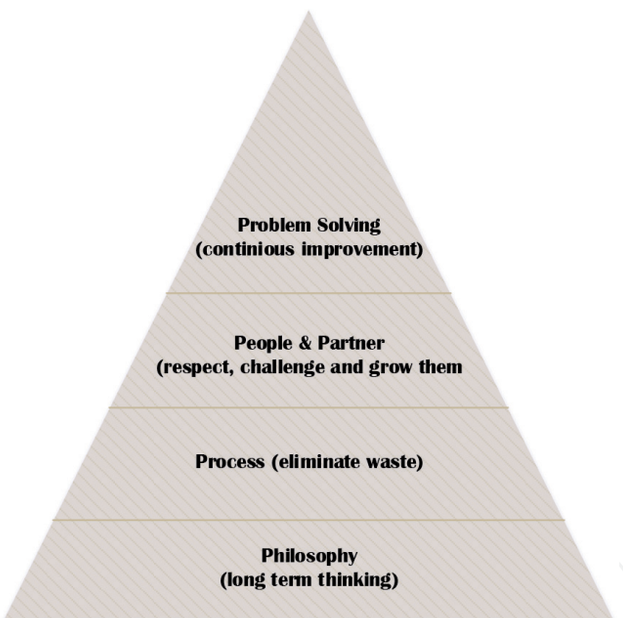

Figure 3.
The 4P of the lean way [10].

Koskela [17] also defined the principles (11 principles) adopted in lean thinking as Liker [10]. The main theme of the lean principles proposed by the two authors is similar to that of Womack and Jones [6] in the 5-step model. This theme consists of defining the value, providing the flow, solving problems with lean techniques and aiming to reach perfection.

3. Lean techniques

Within the scope of lean thinking, there are numerous methods used to reach the targets and minimize the wastes. Some of the lean methods for becoming lean as a system are crucial in the lean systems such as value stream mapping (VSM),

single minute exchange of dies (SMED), the 5S system, one piece flow, just in time (JIT), pull system (Kanban), Poka-Yoke, total productive maintenance, Kaizen, visual controls/management, 5 whys (5N), standardized work, spaghetti diagram, DMAIC, PDCA and so on [12] and they will be briefly described in this section.

3.1 Single minute exchange of dies (SMED)

SMED method is developed by Shingo in the 1950s and later perfected by Toyota over the years [18]. SMED has become the best practice to simplify and reduce the time spent on set up. Time is very important in lean systems and is not expected to be wasted. That's why, this method has an important place in lean techniques. Thanks to SMED method, changeover time is reduced from hours to minutes. In simple terms, it is attempted to decrease the preparation time on a machine or any process to less than 10 minutes [12]. Perhaps the best example of the application of this method is automobile racings.

Set up times is separated as internal and external. The activities performed by stopping the machine are called the internal set up time, while the activities carried out around the machine without stopping the activity are called external set up time [19]. In this point, some of the internal tasks may need to be converted to external tasks without stopping the machine [20]. Thus, continuous flow can be achieved and processes become faster and more efficient. With the improvements in internal set up time, labor savings are achieved and the downtimes of the machine decrease. Moreover, improvements to external set up times do not have a direct impact on stopping time, but may give operators the freedom to take time for other activities.

3.2 The 5S system

The 5S system is a visual communication technique that enables the working area to be well organized [11]. It also helps to reduce waste in the working area through general cleaning. This method is preferred when it is aimed to ensure cleanliness and organized workplace layout, to improve processes, to ensure transparency and to rise up employee satisfaction. Five Japanese words, starting with the letter *S*, are used to create this method. These words are *seiri-sort*, *seiton-straighten*, *seiso-shine*, *seiketsu-standardize* and *shitsuke-sustain* [13]. Buesa [21] stated that some experts add two new terms are safety and security. Lastly, with the implementation of the 5S cycle, it is possible to change the working environment with low costs. Moreover, employees respect to their organizations and themselves, and inventory and material costs are decreased.

3.3 One piece flow

By the one-piece flow technique, it is intended to move a single piece at a time between operations. The one-piece flow method takes into account factors such as sorting jobs, calculating installation time, and determining job shop production policy [19]. Therefore, these factors need to be examined during production planning. Planning a production according to one-piece flow is an important component of lean production strategy. The installation time, the stock levels and the delivery time are directly affected by the lot size. In view of these situations, it is very important to be an agile business to respond to customer needs without creating inventory [12]. This can be achieved by reducing the lot size in lean production.

3.4 Just in time (JIT)

The just in time philosophy adopted by Toyota is a system that regulates the stock level and optimizes the flow of materials. According to the JIT production strategy,

what is needed is produced in the desired amount and time [22]. In this concept, the production of more than the amount needed and stocking are considered as waste. Thus, wastes in processes are eliminated by using the JIT philosophy. Furthermore, the quality-related problems are easily identified thanks to the low level of inventory. In addition to these advantages, JIT offers businesses the flexibility and speed required to keep up with global competition.

3.5 Pull system/Kanban

In lean thinking, workflows are usually applied with the pull system. The pull system is defined as the system by which the customer decides to start production or service [23]. In this system, since the production is started when there is demand, the wastes like excess inventory and overproduction is prevented. In addition, the companies that decide to implement the pull system must fulfill their customer demands within a certain time frame. For this purpose, it is inevitable to use *Kanban* cards. Kanban cards is a Japanese term given to cards used to control the flow in the process such as inventory control [19]. Additionally, control of the variations in demand and production can be provided with Kanban cards [24].

3.6 Poka-Yoke

A Japanese word, Poka-Yoke, means mistake proofing and error avoidance [25]. In this way, errors are detected at the source and prevented from passing to the next step. The basic principle of the technique is to reduce the cost by reducing the number of defective parts that can occur during the production process to zero [26]. Poka-Yoke is preferred for quality at the source. Moreover, the Andon technique, which consists of lights that make it appear when errors occur, are also used.

3.7 Total productive maintenance

Lean systems attach importance to continuous flows. The businesses want to avoid as much as possible the failures and machine errors that may occur during the process. For this reason, total productive maintenance (TPM) technique, should be implemented as routine preventive maintenance with the participation of all employees. TPM is an approach that requires the participation of all the employees within the daily production activities, which also brings the necessity of the maintenance of the equipment that it works on, prevents the errors and maximizes the efficiency of the equipment [27]. However, it is necessary to provide interdepartmental trainings to employees for this maintenance.

3.8 Kaizen

The main philosophy of lean system is the adoption of continuous flow and improvement. All other lean methods try to achieve this philosophy to perfection [28]. Kaizen, based on the concept of continuity, is a process improvement program that will never end. In order to make improvements in the existing production system and to find solutions to the problems identified, employees from different disciplines must come together in the Kaizen activities. In this meeting, wastes are defined and attempts are made to prevent the occurrence of other wastes. Lastly, the main basis of continuous improvement is undoubtedly the fact that top management believes the lean philosophy and provides full support to employees.

3.9 Spaghetti diagram

The spaghetti diagram is the visualization of the movement and transportation of the product or service in the value stream [29]. Employees can collect the data via this method [13]. Because the movements of products and services are clearly visible with this activity. Thus, the wastes during the flow can be easily determined. Besides, the problem determination and solution suggestions for eliminating non value added work steps and distances can be collected with the help of the opinions of the employees.

3.10 Whys (5N)

The 5N method is briefly the process of defining and writing specific problems. As it is understood from this definition, it is questioned why the problems arise and their answers are written under the determined problem. If the answer is not the root cause of the problem [13, 30], the evaluators will continue to ask until the root cause is determined. In the 5N method, it is tried to eliminate the wastes by asking the questions of the cause and the reason causing this problem [31]. In this way, the root of the problem is determined and solved not to occur again.

3.11 Standardized work

The standardization of works and processes has been developed based on the kaizen philosophy [32]. In order to ensure continuous flow, it is necessary to repeat the processes with the same quality every time. By using the standardized work method for repetitive tasks, employees will be trained in the steps of the processes according to the predetermined standards, which will allow quality improvement. Moreover, as employees know exactly what to do, their work satisfaction and motivation increase.

3.12 Visual controls/management

Visual control is a method based on organizing the working area so that management and workers can understand whether there is something going wrong in a way. The use of visual control method wherever the process takes place and its adoption can be evaluated as visual management. By using simple visual schemes, the communication between the employees becomes clear and the areas of responsibility of the employees can be determined by ground lines. In this way, processes can be viewed visually, employees are not forced and errors are prevented.

3.13 DMAIC and PDCA cycle

DMAIC and PDCA are cycles that monitor and examine business processes from start to finish. DMAIC (define-measure-analyze-improve-control) is an integral part of the six sigma method. This method is a systematic and result oriented. If there is flexibility during the processes, the most effective results can be obtained from this method. In addition, steps that do not add value are eliminated [33].

The PDCA (plan-do-check-act) cycle was first developed by Shewhart [12]. This method is more effective than the philosophy of doing it right the first time. Because, by using the PDCA cycle, better improvement methods are sought [33]. PDCA cycle consist of for stages: planning for improvement, doing improvement actions, checking the implications of improvement actions, and making effective permanent actions

Classification	Lean tools & methods
Assessment	Value stream mapping, 5 Whys (5N), A3, Ishikawa diagram, process mapping, Gemba walking
Improvement	5S's, spaghetti diagram, continuous flow, Kaizen, pull system/Kanban, one-piece-flow, Poka-yoke, team approach to problem solving, workload balancing, Andon, Jidoka, process redesign, Heijunka, physical work setting redesign, standardized work
Monitoring	Visual control
Assessment/improvement/monitoring	DMAIC (define-measure-analyze-improve-control), PDCA (plan-do-check-action)

Table 2.
Lean tools and methods and their classifications [35].

toward improvement. In these methods, precise measurements of product and process variability are made. In addition, all processes focus on statistical control [34].

Thanks to these lean tools and methods, to adopt the lean philosophy becomes easier; at the same time the philosophy is ensured to become permanent. These techniques are also thought to eliminate waste in production and service processes. Moreover, the lean methods are divided into three categories by Radnor et al. [2] as assessment, improvement and monitoring. In addition, these methods that frequently preferred in the literature are classified by Costa and Filho [35] the frame of three categories (**Table 2**).

VSM is the most important and most widely used method. In addition, since VSM forms the main framework of this chapter, it is examined in more detail in the next section.

4. Value stream mapping

As a result of increasing interest in lean thinking, executives strive to transform their processes into a lean system. Lean techniques help ensure the lean in processes. One of the commonly applied lean methods is the value stream mapping (VSM) method introduced by Rother and Shook [36].

VSM is a demonstration of whole activities that value added and non-value added in processes by using a pen and paper [36]. VSM; a technique that helps determine and understand the resource and information flow of a product or service throughout the process. It is desirable to eliminate the wastes in the value stream in this method [29].

The aim of the method is to identify activities that non-value added to the product or service in the eyes of the customer and to improve the process by eliminating the wastes. The steps of the VSM method created to accomplish this aim are shown in **Figure 4** [36–38]:

The first step in VSM is the selection of product family with common features or similar processes to avoid complexity. Then, the current state map showing the current process is drawn. What is important here is that the entire process from supplier to customer is included in the map. In the third step, the situations necessary for the development of the process that is dealt with the future state map are mapped. The color of the third step is different because VSM has no meaning if improvements are not recommended after the current state map [36]. In the last

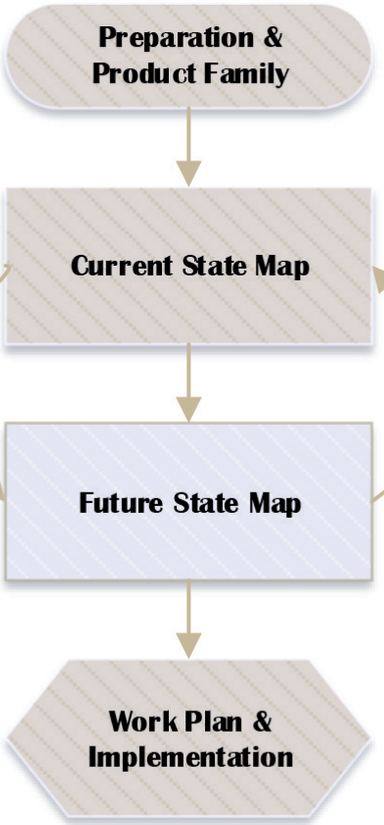

Figure 4.
The value stream mapping process.

step, based on the elements identified on the map, it is discussed and applied what needs to be done, how much time is needed, who should take responsibility in each field and what the expected outcome from each activity is.

Standard symbols are accepted for demonstrating material flow, information flow and general information in VSM [23]. Some icons representing these symbols are provided in **Figure 5**.

The use of the VSM method has several advantages. Advantages of VSM method are listed below [18, 39]:

- ensures that the examined process is handled from beginning to end
- provides visuality thanks to symbolic representation
- procure the identification of the resources causing waste during the process.
- shows the relationship between information flow and material flow
- includes different application steps and implementation plan for continuous improvement

In addition, VSM method determines the system's takt time, lead time and cycle times. In this way, the result of improvements in the future state map can be revealed. The terms here are briefly defined (see [19, 40]):

- *Takt time* is the speed at which goods or services must be produced to meet customer demand. Takt time is calculated by dividing the daily total production time by daily customer demand.

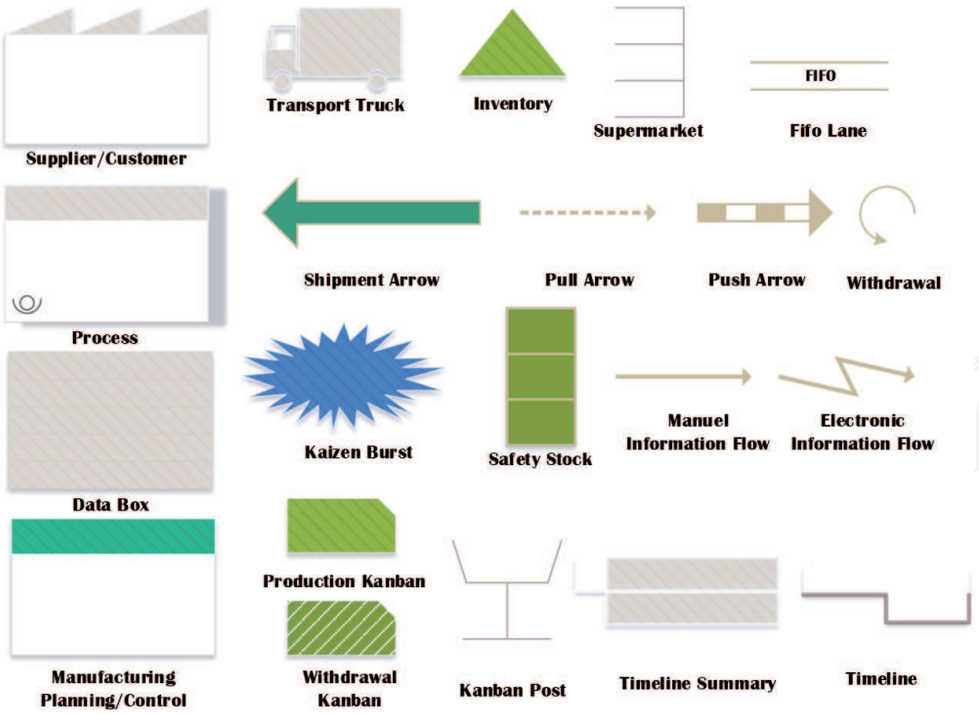

Figure 5.
Value stream mapping icons.

- *Lead time* (in days) is calculated by dividing the number of inventories between the processing steps into the daily demand.

- *Cycle time* is expressed as the maximum time spent on a unit in each station. Cycle time is calculated with a simple formula: 1/output rate per hour in units.

5. Sector specific applications of VSM

For a better understanding of the subject, it will be useful to support the VSM method with examples. In line with this purpose, two examples, one of them from service sector and other from production sector are given.

5.1 Service sector example

The first example is from the service sector. The graduation, specifically the exmatriculation process of university students is selected. As aforementioned earlier in this chapter, the first stage of the VSM method is the identification of the product/service family. Here; the exmatriculation process of a university is determined as the product family. Then, the current situation of the flow in this process is observed and the current state map (CSM) is created (**Figure 6**). As seen in **Figure 6**, there are 12 steps in this process. The flow starts with "transcript control" step and ends with "completion of process". In this map, various wastes stand out. For instance, unnecessary motions (meeting with advisor step), defects (meeting with advisor step), over processing (paper-work and head of department steps), waiting (head of department and filling out the survey steps), and inventory between processes (between department secretary and filling out the survey steps). A future state map (FSM) is drawn in order to eliminate these wastes (**Figure 7**). The first suggestion is that, student information system should be used actively. Moreover, various lean methods are proposed to eliminate the wastes generated during the processes. These lean methods are 5S, Poka-Yoke, quality at the source, kaizen, balanced work flow,

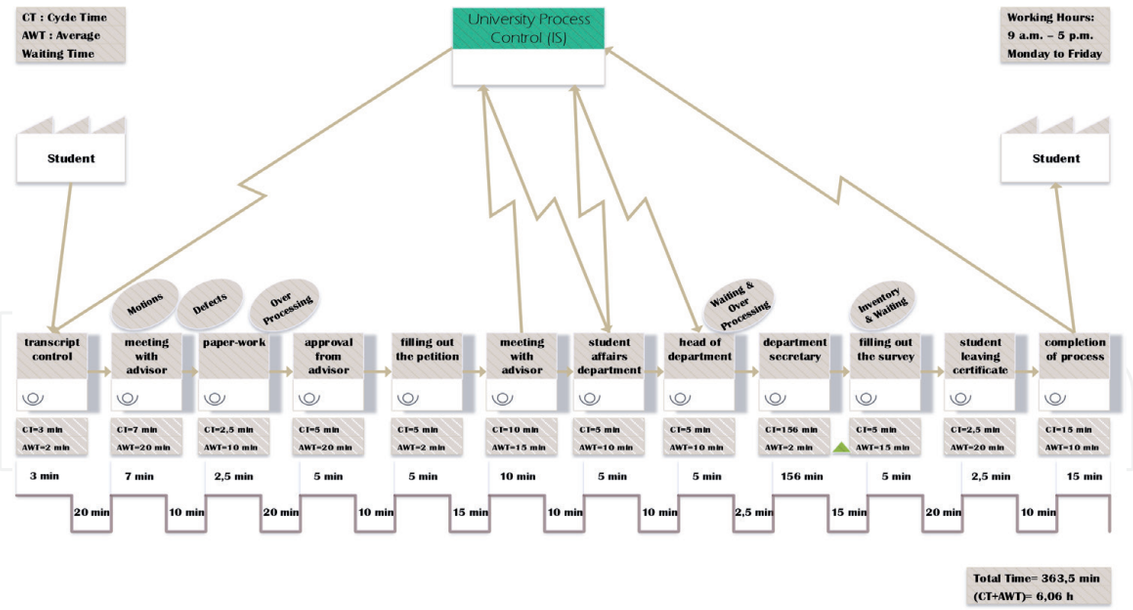

Figure 6.
Current state map (service sector).

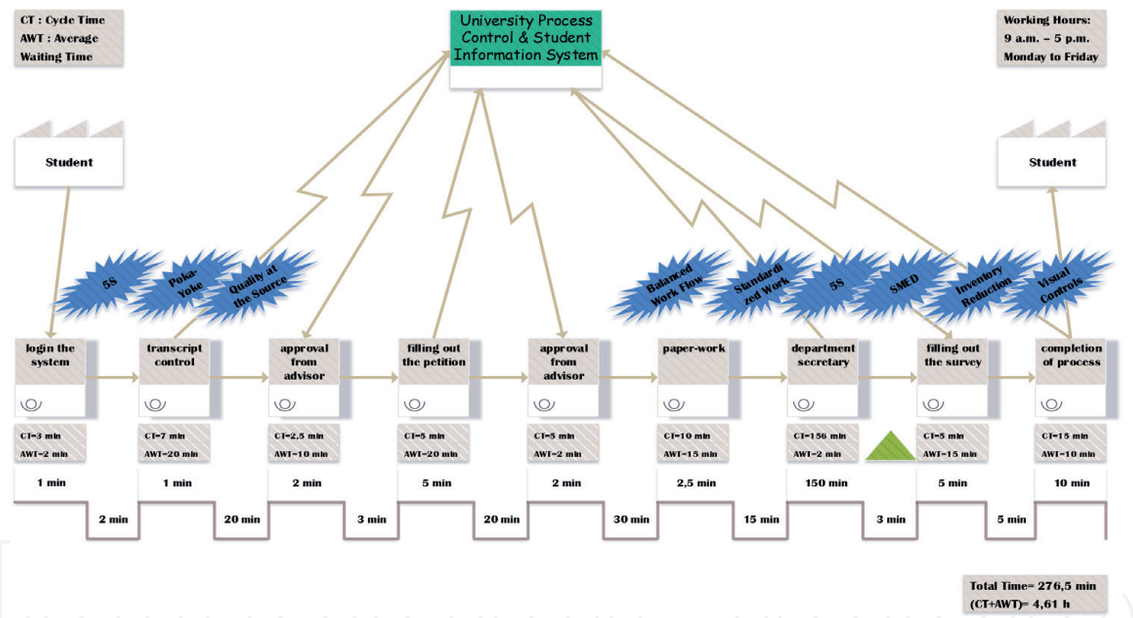

Figure 7.
Future state map (service sector).

standardized work, SMED, inventory reduction and visual controls. If the CSM (**Figure 6**) and FSM (**Figure 7**) are compared simultaneously, it is possible to see the wastes and how to eliminate them. As a result, while continuous flow is achieved, the total time is reduced from 363.5 to 276.5 minutes. This indicates an improvement of 0.24% in the process. In addition, resources are used efficiently and customer (student) satisfaction is ensured.

5.2 Production sector example

For the production sector application, a furniture factory is chosen. One of the sofa model (model A) produced in the furniture company is examined under VSM method (this example is derived from study of Dogan and Takcı [41]). Model A is now the product family of this example. As the second stage of VSM, the steps

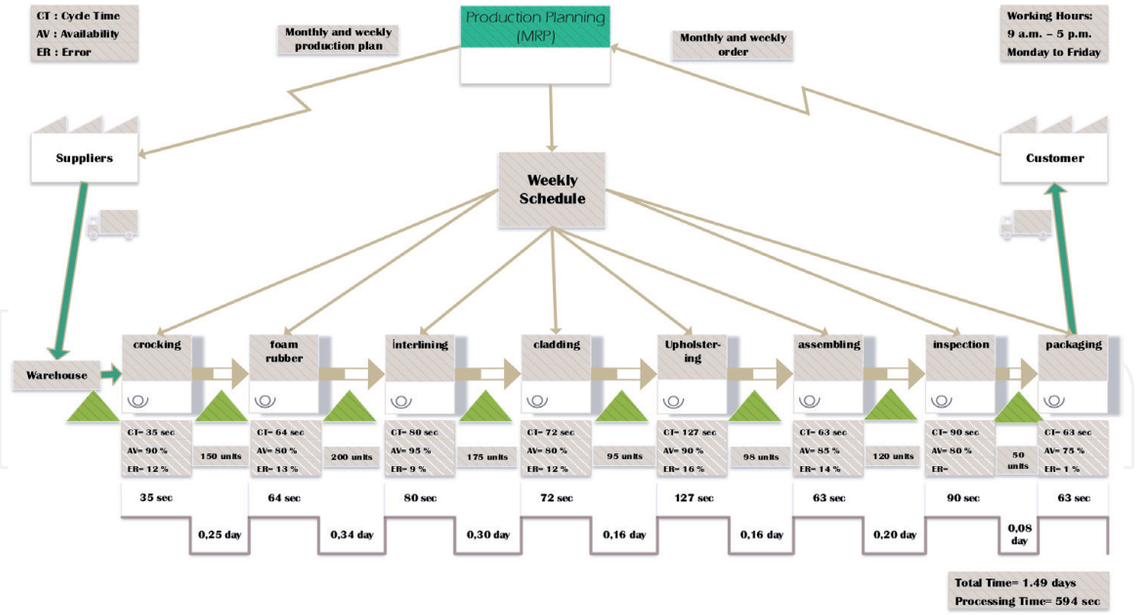

Figure 8.
Current state map (production sector).

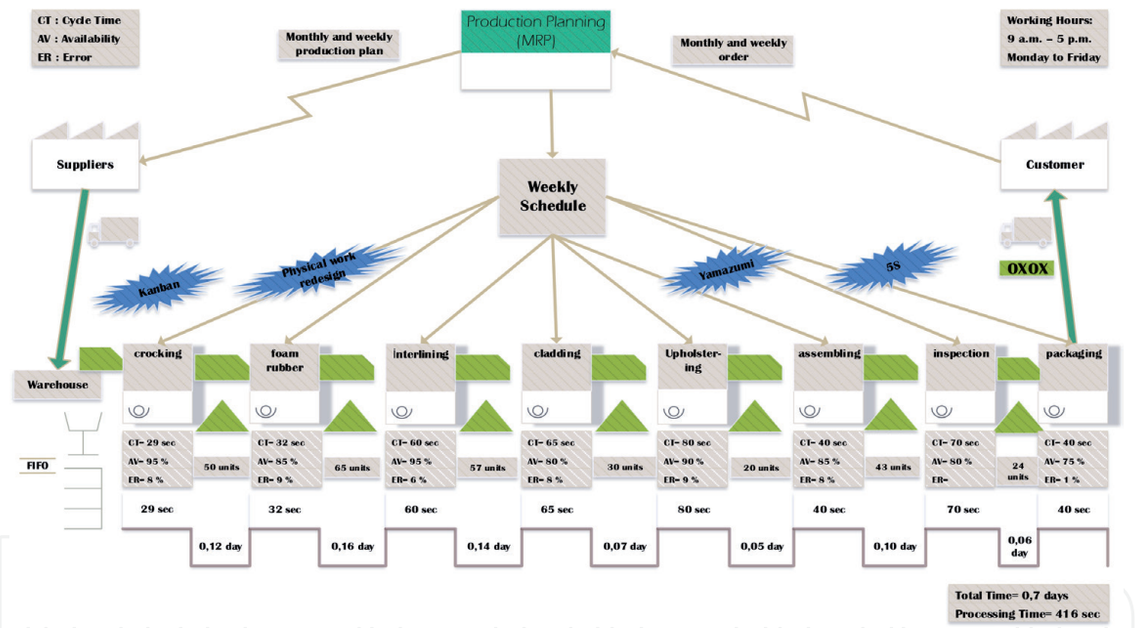

Figure 9.
Future state map (production sector).

in the production phase of Model A are focused. The current state map (CSM) demonstrating this process is shown in **Figure 8**. There are eight production steps in CSM (**Figure 8**). Production flow starts with "crocking" and ends with "packaging". When the current state map is analyzed, it is seen that the total time is 1.49 days and the processing time is 594 seconds. By drawing the CSM, some problems have emerged in the production area. The main problems are as follows: intermediate inventories between the processes; unbalanced workload; time losses due to the inadequate supply of the material and time losses cause quality errors (average 9.62%); time losses due to layout problem, unnecessary transportation and deficiencies like material identification. Then, to eliminate the problems identified with the CSM, a future state map (FSM) is drawn (**Figure 9**). In the FSM, the Kanban system is established, the pull system is applied to prevent accumulated intermediate inventories between the processes and the material transfer is

controlled by FIFO. In addition, Yamazumi is proposed for balancing the workload and minimizing the quality errors and establishment of the Kanban system makes it possible to prevent time losses in production due to the lack of timely supply of the materials. Finally, it may be preferable to use 5S and physical work redesign in order to prevent the time losses due to the layout problem and the deficiencies in the material identification. Analysis of the production process of model A by VSM method showed that continuous flow is achieved; a decrease of approximately 53% in the total time, a decrease of 30% in the processing time and a 36% improvement in the quality error rate. As in the example of the service sector, when the CSM (**Figure 8**) and FSM (**Figure 9**) for production process of model A are examined simultaneously, the wastes, errors, defects and at the same time, improvements in the processes can be clearly seen.

6. Discussion

Lean thinking is the general framework of the implementation of the lean philosophy in the production and service sectors [42]. As stated by Womack and Jones [8] *"lean thinking is lean because it provides a way to do more and more with less and less—less human effort, less equipment, less time, and less space—while coming closer and closer to providing customers with exactly what they want."* LT is an endless process and implementation of continuous improvement. For continuous improvement, researchers and professionals prefer various lean methods like VSM, 5S, SMED, balanced work flow, standardized work etc. The primary purpose of these methods is to eliminate waste and ensure continuous flow.

Value stream mapping is one of the most preferred methods in literature. This is the mapping of the whole process. Mapping the stages of a process, will assist to discover the opportunities for improvement and prevent the loss of time and money of stakeholders [43]. VSM applications, with the aim of eliminating waste are not restricted to a single business; it can also be applied to the supply chain by focusing on all the steps from the first supplier to the end customer. The essence of the matter is that, VSM can be effectively used in all processes if a product or service flow exists.

7. Conclusion

This chapter has focused on lean philosophy and lean methods, especially the VSM. The motive for the detailed examination of the VSM method is that VSM is the first step to overcome how the lean production will be applied. The reason why this method is first preferred is that the whole operation is seen as a holistic approach, and at the same time, it proposes a prescription to eliminate errors and/or wastes. On the other hand, like many other methods, this method has also some limitations. Mapping complex systems with VSM can sometimes be difficult. At this point, large wastes or resources of wastes may be unnoticed. This can be a major problem in VSM, whose main goal is revealing and eliminating waste. Moreover, rather than using the VSM method alone, using with other lean methods will increase the reliability and efficiency of the results. To overcome these weaknesses, it is recommended to benefit from other methods together with the VSM method. For instance, theory of constraints, flowcharts, artificial intelligence and simulation are some of the methods that can be used with VSM.

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References

[1] Dhandapani V, Potter A, Naim M. Applying lean thinking: A case study of an Indian steel plant. International Journal of Logistics Research and Applications. 2004;**7**(3):239-250. DOI: 10.1080/13675560412331298491

[2] Radnor ZJ, Holweg M, Waring J. Lean in healthcare: The unfilled promise? Social Science & Medicine. 2012;**74**(3):364-371. DOI: 10.1016/j.socscimed.2011.02.011

[3] Bhasin S, Burcher P. Lean viewed as a philosophy. Journal of Manufacturing Technology Management. 2006;**17**(1):56-72. DOI: 10.1108/17410380610639506

[4] Al-Aomar R, Hussain M. An assessment of adopting lean techniques in the construct of hotel supply chain. Tourism Management. 2018;**69**:553-565. DOI: 10.1016/j.tourman.2018.06.030

[5] Bonaccorsi A, Carmignani G, Zammori F. Service value stream management (SVSM): Developing lean thinking in the service industry. Journal of Service Science and Management. 2011;**4**(04):428. DOI: 10.4236/jssm.2011.44048

[6] Womack JP, Jones DT. Beyond Toyota: How to root out waste and pursue perfection. Harvard Business Review. 1996;**74**(5):140-158

[7] Vlachos I, Bogdanovic A. Lean thinking in the European hotel industry. Tourism Management. 2013;**36**:354-363. DOI: 10.1016/j.tourman.2012.10.007

[8] Womack JP, Jones DT. Lean thinking—Banish waste and create wealth in your corporation. The Journal of the Operational Research Society. 1997;**48**(11):1148-1148. DOI: 10.1057/palgrave.jors.2600967

[9] Leite HDR, Vieira GE. Lean philosophy and its applications in the service industry: A review of the current knowledge. Production. 2015;**25**(3):529-541. DOI: 10.1590/0103-6513.079012

[10] Aziz RF, Hafez SM. Applying lean thinking in construction and performance improvement. Alexandria Engineering Journal. 2013;**52**(4):679-695. DOI: 10.1016/j.aej.2013.04.008

[11] Cohen RI. Lean methodology in health care. Chest. 2018;**154**(6):1448-1454. DOI: 10.1016/j.chest.2018.06.005

[12] El-Haik B, Al-Aomar R. Simulation-Based Lean Six-Sigma and Design for Six-Sigma. New Jersey: John Wiley & Sons; 2006. DOI: 10.1002/0470047720

[13] Melton T. The benefits of lean manufacturing: What lean thinking has to offer the process industries. Chemical Engineering Research and Design. 2005;**83**(6):662-673. DOI: 10.1205/cherd.04351

[14] Ingelsson P, Mårtensson A. Measuring the importance and practices of Lean values. The TQM Journal. 2014;**26**(5):463-474. DOI: 10.1108/tqm-07-2012-0047

[15] Ballard G, Kim YW, Jang JW, Liu M. Road Map for Lean Implementation at the Project Level. Austin: The Construction Industry Institute, The University of Texas: 2007

[16] Liker JK. The 14 Principles of the Toyota Way: An Executive Summary of the Culture behind TPS. The Toyota Way. Vol. 1; 2004. pp. 35-41

[17] Koskela L. Application of the New Production Philosophy to Construction. Vol. 72. Stanford: Stanford University; 1992

[18] King PL, King JS. Value Stream Mapping for the Process Industries:

Creating a Roadmap for Lean Transformation. Boca Raton, Florida: Productivity Press; 2015. DOI: 10.1201/b18342

[19] Sundar R, Balaji AN, Kumar RS. A review on lean manufacturing implementation techniques. Procedia Engineering. 2014;**97**:1875-1885. DOI: 10.1016/j.proeng.2014.12.341

[20] Trovinger SC, Bohn RE. Setup time reduction for electronics assembly: Combining simple (SMED) and IT-based methods. Production and Operations Management. 2005;**14**(2):205-217. DOI: 10.1111/j.1937-5956.2005.tb00019.x

[21] Buesa RJ. Adapting lean to histology laboratories. Annals of Diagnostic Pathology. 2009;**13**(5):322-333. DOI: 10.1016/j.anndiagpath.2009.06.005

[22] Monden Y. Toyota Production System: An Integrated Approach to Just-In-Time. Boca Raton, Florida: Productivity Press; 2011. DOI: 10.1201/b11731

[23] Krajewski LJ, Ritzman LP, Malhotra MK. Operations Management: Processes and Supply Chains. Upper Saddle River, New Jersey: Pearson; 2010

[24] Junior ML, Godinho Filho M. Variations of the Kanban system: Literature review and classification. International Journal of Production Economics. 2010;**125**(1):13-21. DOI: 10.1016/j.ijpe.2010.01.009

[25] Grout JR, Toussaint JS. Mistake-proofing healthcare: Why stopping processes may be a good start. Business Horizons. 2010;**53**(2):149-156. DOI: 10.1016/j.bushor.2009.10.007

[26] Fisher M. Process improvement by Poka-Yoke. Work Study. 1999;**48**(7):264-266. DOI: 10.1108/00438029910294153

[27] Ahuja IPS. Total productive maintenance. In: Handbook of Maintenance Management and Engineering. London: Springer; 2009. DOI: 10.1007/978-1-84882-472-0_17

[28] Earley J. The Lean Book of Lean: A Concise Guide to Lean Management for Life and Business. United Kingdom: John Wiley & Sons; 2016. DOI: 10.1002/9781119271703

[29] Wilson L. How to Implement Lean Manufacturing. New York: McGraw-Hill; 2010

[30] Card AJ. The problem with '5 whys. BMJ Quality and Safety. 2017;**26**(8): 671-677. DOI: 10.1136/bmjqs-2016-005849

[31] Ayad A. Critical thinking and business process improvement. Journal of Management Development. 2010;**29**(6):556-564. DOI: 10.1108/02621711011046521

[32] Berger A. Continuous improvement and kaizen: Standardization and organizational designs. Integrated Manufacturing Systems. 1997;**8**(2):110-117. DOI: 10.1108/09576069710165792

[33] Sokovic M, Pavletic D, Pipan KK. Quality improvement methodologies-PDCA cycle, RADAR matrix, DMAIC and DFSS. Journal of Achievements in Materials and Manufacturing Engineering. 2010;**43**(1):476-483

[34] Stanton P, Gough R, Ballardie R, Bartram T, Bamber GJ, Sohal A. Implementing lean management/six sigma in hospitals: Beyond empowerment or work intensification. The International Journal of Human Resource Management. 2014;**25**(21):2926-2940. DOI: 10.1080/09585192.2014.963138

[35] Costa LBM, Godinho Filho M. Lean Healthcare: Review,

classification and analysis of literature. Production Planning and Control. 2016;**27**(10):823-836. DOI: 10.1080/09537287.2016.1143131

[36] Rother M, Shook J. Learning to See. Cambridge, MA: Lean Enterprise Institute; 1999

[37] Belokar RM, Kumar V, Kharb SS. An application of value stream mapping in automotive industry: A case study. International Journal of Innovative Technology and Exploring Engineering. 2012;**1**(2):152-157

[38] Keyte B, Locher DA. The Complete Lean Enterprise: Value Stream Mapping For Administrative and Office Processes. Boca Raton, Florida: Productivity Press; 2016

[39] Mazur LM, Chen SJG. Understanding and reducing the medication delivery waste via systems mapping and analysis. Health Care Management Science. 2008;**11**(1):55-65. DOI: 10.1007/s10729-007-9024-9

[40] Zidel T. A Lean Guide to Transforming Healthcare: How to Implement Lean Principles in Hospitals, Medical Offices, Clinics, and Other Healthcare Organizations. Milwaukee, Wisconsin: ASQ Quality Press; 2006

[41] Dogan NÖ, Takci E. Transition to lean production: Value stream mapping application in a manufacturing firm (Yalın Üretime Geçiş: Bir İmalat İşletmesinde Değer Akış Haritalama Uygulaması). In: Proceedings of the International Symposium for Production Research (UAS'15); Izmir, Turkey. 2015. pp. 497-504

[42] Doğan NÖ, Unutulmaz O. Lean production in healthcare: A simulation-based value stream mapping in the physical therapy and rehabilitation department of a public hospital. Total Quality Management & Business Excellence. 2016;**27**(1-2):64-80. DOI: 10.1080/14783363.2014.945312

[43] Womack JP, Jones DT. Lean consumption. Harvard Business Review. 2005;**83**(3):58-68. DOI: 10.1049/me:20050512