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ONGOING IMPROVEMENT OF PRODUCTION PROCESSES

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THE DREAM THAT CAME TRUE AND THE NEED TO CONTINUOUSLY IMPROVE PRODUCTION PROCESSES

O SONHO QUE VIROU REALIDADE E A NECESSIDADE DE MELHORIA CONTÍNUA
DOS PROCESSOS DE PRODUÇÃO

EL SUEÑO QUE SE HIZO REALIDAD Y LA NECESIDAD DE MEJORÍA CONTINUA EN
LOS PROCESOS DE PRODUCCIÓN

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ABSTRACT

Dilemma: This study case depicts the dilemma of a company specialized in producing multi-laminated plywood sheets, which after fifteen years in the market, is seeking strategies for ongoing improvement aimed at reducing waste in the production process.

Educational objective: The educational objectives are: (a) to identify and differentiate types of demand and their impacts on the value chain; (b) to evaluate processes from the perspective of Lean Manufacturing philosophy and (c) to illustrate how good ongoing improvement practices can help reduce waste.

Contextualization: After bringing to fruition a long dreamed-of business among friends, its managers must now map and minimize raw material waste.

Main theme: The central theme of the case is the philosophy of Lean Manufacturing and its tools for continual improvement, especially Value Stream Mapping (VSM).

Audience: This case was written for use in graduate courses in Administration, Logistics and Production Engineering.

Limitations: Despite the relevance of the topic within an organizational context, the case study took place in 2015.

Originality/value: The writing of the case presents a logic that enables students can design the VSM, exercising their ability to analyze processes and stimulating their creativity to solve problems under the pillars of the philosophy addressed.

Keywords: Lean Manufacturing. Ongoing improvement. Production process. Waste reduction. Teaching case.

RESUMO

Dilema: Este caso para ensino retrata o dilema de uma empresa especializada em produzir chapas de compensado multilaminadas que, após 15 anos de mercado, tem buscado estratégias para melhoria contínua visando à redução de desperdícios no processo produtivo.

Objetivo educacional: Os objetivos educacionais são (a) identificar e diferenciar tipos de demanda e seus impactos na cadeia de valor; (b) avaliar processos sob a ótica da filosofia do Lean Manufacturing e (c) ilustrar como as boas práticas de melhoria contínua podem auxiliar na redução de desperdícios.

Contextualização: Após a consolidação do tão sonhado negócio entre amigos, os seus administradores se veem desafiados a mapear e minimizar os desperdícios de matéria-prima.

Tema principal: O tema central do caso é a filosofia do Lean Manufacturing e suas ferramentas de melhoria contínua, especialmente o Mapeamento do Fluxo de Valor (MFV).

Público: Este caso foi escrito para ser utilizado em cursos de graduação em Administração, Logística e Engenharia de Produção.

Limitações: Apesar da relevância do tema dentro de um contexto organizacional, a história do caso ocorreu em 2015.

Originalidade / valor: A redação do caso apresenta uma lógica para que os alunos possam desenhar o MFV, exercitando sua capacidade de análise de processos e estimulando a criatividade para resolução de problemas sob os pilares da filosofia abordada.

Palavras-Chave: *Lean Manufacturing*. Melhoria contínua. Processo produtivo, Redução de desperdícios. Caso para ensino.

RESUMEN

Dilema: Este caso para enseñanza retrata el dilema de una empresa especializada en producir placas de compensado multilaminado, que, al cabo de 15 años en el mercado, ha buscado estrategias para su mejoría continua, con el fin de reducir desperdicios en el proceso productivo.

Objeto educacional: Los objetivos educacionales son: (a) identificar y diferenciar los tipos de demanda y sus impactos en la cadena de valor; (b) evaluar procesos con la óptica de la filosofía de *Lean Manufacturing*; (c) ilustrar cómo las buenas prácticas de mejoría continua pueden auxiliar en la reducción de desperdicios.

Contextualización: Luego de la consolidación del tan soñado negocio entre amigos, sus administradores se encuentran desafiados a mapear y reducir los desperdicios de materia-prima.

Tema principal: El tema central del caso es la filosofía del *Lean Manufacturing* y sus herramientas de mejoría continua, especialmente el Mapeamiento de Flujo de Valor (MFV).

Público: Este caso fue escrito para ser utilizado en cursos de grado en Administración, Logística e Ingeniería de Producción.

Limitaciones: A pesar de la relevancia del tema dentro de un contexto organizacional, la historia del caso ocurrió en 2015.

Originalidad/valor: La redacción del caso presenta una lógica para que los alumnos puedan diseñar el MFV, ejercitando su capacidad de análisis de procesos y estimulando la creatividad para resolución de problemas sobre los pilares de la filosofía abordada.

Palabras clave: *Lean Manufacturing*. Mejoría continua. Proceso productivo. Reducción de desperdicios. Caso para enseñanza.

INTRODUCTION

It was early 2015, a Friday, the end of the day, and José was thinking of a solution to a problem he had observed for some time: the waste of raw materials. Every day, he would notice pieces of wood thrown around the corners of the factory, leftovers from production, which were then discarded in the dumps in large quantities. He could not accept this; he wanted to find a way to minimize the impacts of this damage to the company. He was a partner, and was responsible for purchasing logs for Wood's Valley, a sawmill specializing in producing multi-laminated plywood sheets, located in a small town in the interior of Santa Catarina.

After much thought, he gathered information and went home, intending to talk with the company manager on Monday morning about what he had discovered. Over the weekend, he pondered the possible reasons. Perhaps it could be that the equipment was too old, but they had already made several investments, including on some new machines that would be arriving soon. So was it just a lack of maintenance? Did the employees probably need more training, or supervision of production activities?

José felt that it would be beneficial to map the current situation and think of a solution to better manage the production process, identify the reasons for the waste, minimize it, create routines (value flow) and improve results. But how could this be done?

A DREAM FULFILLED

At the beginning of 2000, three friends, José, Frederico and Estevão, shared the same desire: to build something they could leave as a legacy; something that, besides bringing them profit, would also bring employment and benefits to society. José, now retired, had worked for thirty years in a multinational company and over that time, he had acquired property and real estate, accumulating good personal assets, as a result of his business skills and his entrepreneurial flair. Frederico and Estevão ran their own businesses and were not thinking of giving up those business any time soon.

One day, José learned that an industrial shed, belonging to a beverage distributor, was going to be put up for auction. He thought it would be a great opportunity, so he searched for more information, which he took to Frederico and Estevão.

- Hey guys, I heard about a business that could be an opportunity for us to fulfill our dream of building up some equity together.

- What is this opportunity, and how could it benefit to us? - The friends replied.

- The shed that belonged to the beverage distributor that went bankrupt is going up for auction. If we managed to buy it, we would have somewhere to start a new business. But the price is high, we can't afford it ourselves, so we'll need to look for others who are interested in forming a partnership.

After a long conversation, they decided to look for other well-established entrepreneurs who could help them pay the amount required to purchase the shed. The plan was shared with other friends, and the group grew to thirteen members. To discuss the long-dreamed of project, a meeting was scheduled with the future partners, led by José:

- The initial plan is to purchase the warehouse at auction, with the goal of starting a new business, which can generate jobs and benefits to society, as well as bringing a profit for us all.

Some members of the group wanted to know more about the business, but Luiz and Vitor accepted the proposal right away, as they trusted their friend completely. They had worked for the same multinational company where José was the boss, so they knew him well and trusted his vision and entrepreneurial ability. The other members of the group asked more questions, and agreed to form a partnership. It took dozens of meetings to define how the company would be constituted and the field of activity in which it would operate. Thus, in mid-2000, the company União do Vale (provisional) was born, with the aim of producing multilaminated plywood sheets. This field of work was chosen due to the readily available labor force in the city, as the local textile industry employed almost exclusively women, leaving many men looking for work. Also, the wood laminates market was on the rise, which promised prosperity for the company.

And what next, José?

After defining the constitution of the company and its field of activity, the challenge was to search for somebody to run it. All the partners already had their own businesses to run, or were already employed elsewhere. So a search was conducted for someone to take on this position of great importance and responsibility within the company.

Luiz, the youngest of the partners, worked at the multinational company and had a good position there. However, the headquarters of the company where he worked was ninety kilometers away from his home. During the week, he would stay travel to the city to work, and on weekends he would return home. On one of these trips, Luiz thought about the possibility of taking over the running of the new company, as he had grown tired of traveling back and forth so much. It was stressful, and the condition of the roads was poor. He considered the pros and cons, then asked his friend and former boss, José, what he thought of the idea. José listened attentively to Luiz, but advised caution:

- You know it's a new business, we're not sure whether it will be a success. How will you support your family? You have a good job now, with a salary and all the benefits it offers.

After a long conversation, Luiz told José that he had already considered everything and that if his friend and the other partners agreed; he would take over the management of the company. Without hesitation, the partners placed their full confidence in him and gave him the autonomy to manage the business. It was a relief for everyone!

All hands to work!

On November 15, 2000, the company was registered under the name of Wood's Valley, and from then until February 2001, the partners dedicated themselves to the planning, including investments, purchase of equipment, and hiring of employees. All the partners made use of the experience they had gained during their professional lives. The company began operations with just a few employees, purchasing wood veneers from third parties and producing plywood sheets. By the following year, it was already exporting to various countries, including the United States, the Caribbean, the United Kingdom and other countries in Europe. Production was gradually increased as they gained more knowledge in the field, requiring new investments in machinery, equipment and land.

In April 2003, José joined the company's staff, initially assisting in administrative matters and, later, being made responsibility for the purchase of wood. The company's management had major challenges to face, including economic and financial crises, market changes, and the departure of some of the partners. The shares of those who left were absorbed by the other partners of the company, causing decapitalization and an increase in the share participation of the remaining partners. In 2015, the company had 180 employees and its monthly revenue was around R\$ 2.5 million. Figure 1 shows a chronology of key highlights in the company's history.

Figure 1.
Chronology

Year	Event
2000	Acquisition of a shed. Constitution and registration of the company.
2001	Start of operations. Three partners leave the partnership.
2002	Sales to the foreign market. Another partner leaves the partnership.
2003	Acquisition of a 26 hectares of land, which is reforested with pine, for stock and future use.

2004	Acquisition of a five-hectare plot of land and start of construction of the branch. Considerable increase in exports, representing 50% of sales.
2007	Acquisition of a lathe, a dryer and a press, for use in the branch. Increase in exports, now representing 70% of sales.
2008	High level of indebtedness due to purchases of equipment. Decrease in exports due to the global crisis. Quick decision-making to gain more space in the domestic market. Start of operations at the branch.
2010	Recovery and improvement in company results. Focus on the domestic market.
2012	Resumption of exports. Purchase of a new press.
2015	Close of activities at the company's headquarters. All activities transferred to the branch, which becomes the company's only unit in the city.

Source: Prepared by the authors.

The timber company operates with two types of product sales: direct sales and sales through representatives. Direct sales are generally made to companies in the construction industry, which contact the company directly and place their orders. However, this type of sale accounts for only a small portion of the total sales. Commercial representatives are responsible for prospecting customers, issuing orders and following up on after-sales. Each representative has a monthly quota to fill, and all receive commission based on the gross value of sales made.

The company manufactures its products to order, which enables focused production. Its production is planned according to the entry of orders, and this planning is done weekly, on a continual basis. Most orders are for between ten and thirty days in advance, enabling the company to anticipate its monthly purchases (some companies work to a three-month horizon). The company already has a long history of sales, which gives it an understanding of customer behavior and seasonality. The finished products are distributed to the domestic market by road transport, while exports are sent through the maritime ports of Navegantes, Itajaí and Itapoá.

MONDAY ARRIVES

As planned, in the early hours of the day, José told Luiz about the problem he had discovered:

- I've noticed a lot of losses and waste in our production process.

- What kind of losses? – replied Luiz, apprehensively.

- We're wasting a lot of raw material, mainly wood, which could be converted into more sheets. We should monitor the production to try and resolve this problem.

José presented several arguments and the two talked a lot about the subject, without reaching a consensus on the root cause of the problem. They agreed that Luiz would follow, *in loco*, all the stages of the production process to investigate what was happening.

Luiz checks the current situation of the company

Starting in **the yard**, Luiz watched a truck unloading logs, the main raw material for production, acquired monthly from reforestation companies and small producers. He watched for a few minutes and identified that there was a lack of standardization of the dimensions of the logs delivered by the suppliers (Figure 2). "If there are different sizes, there are certainly going to be losses of raw material, as it is not possible to adjust the cut in the lathe for each log", Luiz thought to himself.

Figure 2.
Yard



Source: Image provided by the company.

Still in the yard, he observed the process of **steaming**; the logs are moistened for fifteen hours with steam from the boiler, and covered with tarpaulins to make them more flexible and facilitate the work of the lathe, which is the next production stage (Figure 3). Luiz was satisfied: things were going well, he did not identify any problems, and the sizing of the logs was not causing any bottlenecks in the storage or steaming processes.

Figure 3.
Steaming



Source: Image provided by the company.

He went on to evaluate the next step; the **lathe**, where the logs are cut and defoliated to produce wooden sheets of 1.3mm to 4mm in thickness, and 1.15m to 2.60m in length, depending on the customers' requirements (Figure 4). Luiz knew he would find faults at this stage, due to the old equipment. However there was already provision for the acquisition of at least one new machine.

Figure 4.
Lathe



Source: Image provided by the company.

He watched the process and noticed that the two **lathes** left a residual log, called a roller, with a circumference of between 8cm and 8.5cm. He wondered if there was a way to reduce the circumference of the rollers, and decided to talk to the machine operator:

- Good morning, Antenor! Everything okay?
- Everything is going from strength to strength.

- I'm visiting all areas of the factory, analyzing processes and talking to employees. We want to try and find out if there is any wastage of raw material. Do you think it would be possible for us to make some adjustments to the lathe?

- I think so. We might be able to reduce the size of the roller, but you know our lathes are old. The technician from the maintenance company said that the new machines come with different standardization and that the rollers are much smaller than these ones. Certainly, there would be less waste.

Luiz recalled that Antenor had been trained to work with the machine automatically, but that he sometimes saw him operating it manually. So he asked why they didn't operate it automatically all the time. The employee replied that there are natural faults at the beginning of the logs and that as the set-up had to be changed over for each new order, it was necessary to halt the process and operate manually. "Right now, I'm making a change to fulfill an order that was a priority", Antenor explained. Luiz took some more notes, as he was sure that several problems were occurring in this stage. It might be necessary to adjust the equipment, retrain employees, and review recurring exchanges for priority orders, which were also causing extra losses due to the machine setup.

The visit to the factory was followed by a visit to the **continuous dryer** (Figure 5). This machine dries out the sheets, which have a high moisture content, whether for reasons inherent to the wood itself or because of the period spent under the steam from the boiler.

Figure 5.
Continuous Dryer



Source: Image provided by the company.

Luiz noticed that the employees worked efficiently and showed a willingness to be productive, but he knew that the sheets, being very thin, could break if not handled correctly and if that happens, the sheet cannot be reused. Noting that there was a significant amount of broken sheets, one of the employees asked:

- Carlos, do we have this many leftovers every day?
- It depends, when the dryer is too hot, the sheets break more easily.
- But shouldn't the temperature be standardized?
- It depends on the weather. Sometimes the sheets don't dry out properly and we have to run the sheet through the machine twice. On other days, it's so hot that it breaks easily.

He made more notes and moved on to the **assembly** line, where the sheets are arranged in layers before being glued to the wood (Figure 6). He did not spot any abnormalities there, but asked the employees to be careful when placing the sheets, as if this was not done properly, the sheet can become undulated, or there may be additional losses due to a lack of adjustment of the edges of the sheets, impairing quality and causing some of the sheets to become unusable.

Figure 6.
Assembly



Source: Image provided by the company.

In the next process, called **pressing**, the overlapping sheets go to the press, which gives the required bonding that gives the sheets the required durability (Figure 7). Luiz spoke with employees, who reported that there was movement of the sheets inside the metal plates, sometimes, due to insufficient pressure and/or inadequate temperature and excessive humidity of the sheets. Luiz identified this as a priority area for correction because, being one of the final stages of production; the material has already gone through several stages, causing not only loss of raw material, but also the need for overtime and other inputs.

Figure 7.
Pressing



Source: Image provided by the company.

Next, Luiz visited **the finishing stage**, where the sheets are trimmed and the surfaced is sanded and painted, according to the customer's specifications (Figure 8). He saw that the process was running correctly and had no waste or material handling problems. He checked the quality of the product and deemed it suitable to be taken to stock, before being sent out to the customers.

Figure 8.
Finishing stage



Source: Image provided by the company.

Luiz ended his visit to the factory and checking the entire production process. He left with lots of notes, questions, and resolved to draw up a plan solve these problems.

Clearing things up

After revisiting the production area, Luiz explained to José that he had identified losses were occurring in practically all stages of the production process. Together, they began to study the case, analyzing documents and observing the bottlenecks, and prepared a report that accounted for an annual loss of R\$500 thousand which, if avoided, could revert the amount to the company's cash. This amount was a rough estimation, based on the knowledge of the two partners, and only considered material losses, without including rework and hours wasted in production. The Wood's Valley sawmill was in a period of full production, making it even more essential to reduce losses and waste. Based on the inspection carried out, can the reasons for the waste be mapped? Is it down to a lack of good production management practices? Could correcting these practices help reduce waste?

TEACHING NOTES

Educational Objectives

This is a case with an illustrative typology which, according to Ikeda et al. (2005), aims to describe an event or process, through a real case, to emphasize the barriers or difficulties in the implementation of a concept or model. This teaching case depicts a need to develop monitoring strategies and tools for ongoing improvement, aimed at reducing waste in the production process. The learning objectives of this case are:

- a) To identify and differentiate types of demand and their impacts on the value chain;
- b) To evaluate processes from the perspective of Lean Manufacturing philosophy;
- c) To illustrate how good ongoing improvement practices can help reduce waste.

The case is designed for use in undergraduate courses in Administration, Logistics and Production Engineering. In particular, its use is recommended for classes that are learning about Lean Manufacturing philosophy. The case was tested in April 2021, completely in remote, online form (due to Covid-19) as part of the Production and Operations Management course of the discipline of Business Administration of the Itajaí Campus, UNIVALI. The results showed that the case achieved its objectives, and were essential for validating the terms used and the proposed method.

Data source

The dilemma was based on a real case that occurred in 2015, but is still of relevance to companies of different sizes. The authors have access to the main characters in the story and, as agreed, the names and location of the company have not been revealed. The story was adapted as a teaching case, and the problem was structured for the classroom. Primary data were added from conversations, in person and via messaging and email exchanges. The images attached for support are real and were made available by the company, which granted the right to use them.

Lesson Plan

For application of the case to the indicated target audience, it is suggested that it be conducted in person, in three stages, as summarized in Figure 9.

Figure 9.
Lesson Plan

Stage	1 – Context	2 – Activity	3 – Results
Duration (min)	65	60	55
Educational objectives	a	b	c
Related question	1	2 and 3	2 and 3
Proposed action	Introduction of the Activity (teacher) 5 min	Group work	Group presentations
	Reading the Case (individual) 45 min		Closing (teacher)
	Socialization and discussion in a large group (teacher) 10 min		

Source: Image provided by the company.

In the first stage, the students are asked to read the Case, individually, in the classroom. This is followed by socializing and discussion of the Case, among the whole group. The instructor should ask the students if the company has characteristics of the Lean Manufacturing philosophy, especially considering its type of demand. The students are expected to be able to identify that the company operates with a pull production system; otherwise, it is suggested that this concept be reinforced.

In the second stage, the students are dividing into groups, to design the Value Stream Mapping (VSM) that is required in the second question. If the students are finding this task difficult, show some examples and instruct them to follow the order of the process observed by Luiz, guiding them, in particular, to itemize the waste and reflect on its causes. This should encourage suggestions for other tools for ongoing improvement. The third step is the socialization of group work: ideally, a representative from each team should be chosen to present their team's responses to the questions.

Three hours of class time are estimated for this Case. If time is short, or if the class is being taught remotely (as in our test), it is suggested that the case be made available to read in advance, so that in the first meeting, the Case can be discussed and the context of the activity given, which can be started in class and delivered later. In this scenario, the group presentations and outcomes of the Case would take place in the second meeting.

Questions For Discussion, Analysis And Connection With The Literature.

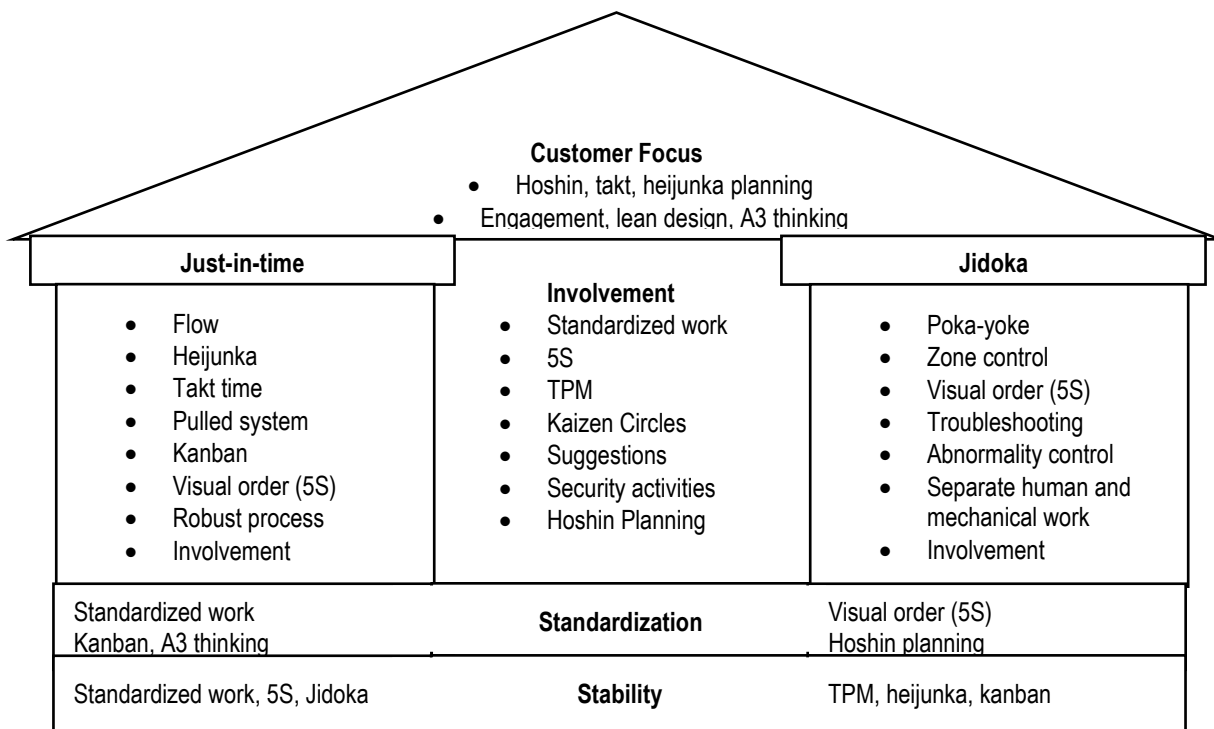
Question 1: It is possible to identify, among the company's forms of sales, the presence of a production method characteristic of the Lean Manufacturing philosophy. How could the company make the best use of this feature?

According to the Lean Institute Brazil (LIB, 2020), the Lean philosophy provides the best quality, the lowest cost and the shortest lead-time through the elimination of waste, based on two pillars: Just-in-Time (JIT - produce the necessary item, at the necessary time, in the necessary quantity) and Jidoka (automation with a human mind). Over the years, many concepts have increased the pillars of Lean, making it difficult to understand its scope. To make the model easier to understand, Fujio Cho developed a diagram to represent the main concepts of Lean production in a simple form (Liker 2007a). This diagram, known as the "Lean Production House", is shown in Figure 10.

Regarding the process flow, one of the main characteristics of the lean philosophy is **the pull system** which, according to Liker (2007b, p. 103), "indicates when the material is moved and who (the customer) determines this movement". In the context presented, it is possible to identify this characteristic at the beginning of the process, dictating the planning and pace of production. Analyzing the excerpt of the case, it is evident that: "The company manufactures its products only upon customer orders, which enables it to direct its production. Its production is planned as the orders come in".

One of the benefits of this system is that it is able to provide the customer with what they want, when and how they want it. But according to Liker (2007b, p. 109), "for this type of flow to work, each operator must have the capacity to produce any model requested at any time". These characteristics of flexibility, customization and customer focus are seen in the excerpt: "the set-ups are changed with each order... I changed the set-up to fulfill an order that was a priority". In addition, the sales proposal deals with customized orders especially to meet the demands of the foreign market, with exports resuming in 2012 (Figure 1).

Figure 10.
Lean Production House



Source: Dennis (2008, p. 38).

The use of pull systems also aims to avoid overproduction and waste of resources, and to minimize inventories through ongoing improvements (Liker, 2007a). This concern with processes and resources is perceived by the initiative of one of the administrators, who states: “We are losing raw material, mainly wood, which could be converted into more sheets”.

Liker (2007a) explains that lean success depends on leadership, team, strategies and relationships with suppliers and a learning orientation. Therefore, the company can take advantage of its solid experience in the market, as highlighted in the excerpt of the case: “the company already has a long history of sales, enabling it to understand customer behavior and seasonality”.

On the other hand, it must replicate the thinking drawn to all stages of production, returning “the Deming principle, the next process is the customer” (Liker, 2007a, p. 43) and, in this way, mitigate variations and losses from the purchase of raw material and throughout the production stages, avoiding situations such as carelessness. This is especially true of the final stages of the process, as noted in the excerpt from the case: “the material has already gone through several stages, causing not only loss of raw material, but also excess working hours and other inputs.” This attention to the current operation, without losing sight of the work already done and the work still to be done, contributes to the lean characteristics of reducing waste and keeping the focus on the customer (whether internal or external).

Three of the five groups surveyed mentioned pull production as the main characteristic, giving their reasons for this. Another two, despite not mentioning the term “pull production”, correctly described the JIT pillar, which covers the concept of pull production, relying mainly on the company's production planning.

Question 2: Taking into account this characteristic and the process analyzed by the manager Luiz, draw the Value Stream Mapping (VSM) of the company's current situation.

After understanding the company's production system, it is necessary to map the current scenario of processes in order to identify opportunities for improvement. One of the Lean philosophy languages that aids in this visualization is the VSM, a flowchart that presents the flow of materials and information from their origin to the end customer, showing opportunities for improvement and enabling a better understanding of the current state of processes (Dennis, 2008; Liker, 2007b). The VSM has symbols for a standard language, as shown in Figure 11. Based on these symbols, it is recommended that the leader visit the plant and document everything he/she sees there, with all the steps of adding value and its inhibitors, bearing in mind that the objective is to understand the current situation and the nature of the processes as a whole, rather than viewing each process in isolation (Liker, 2007b). In the case presented, the leader is represented by the character Luiz.

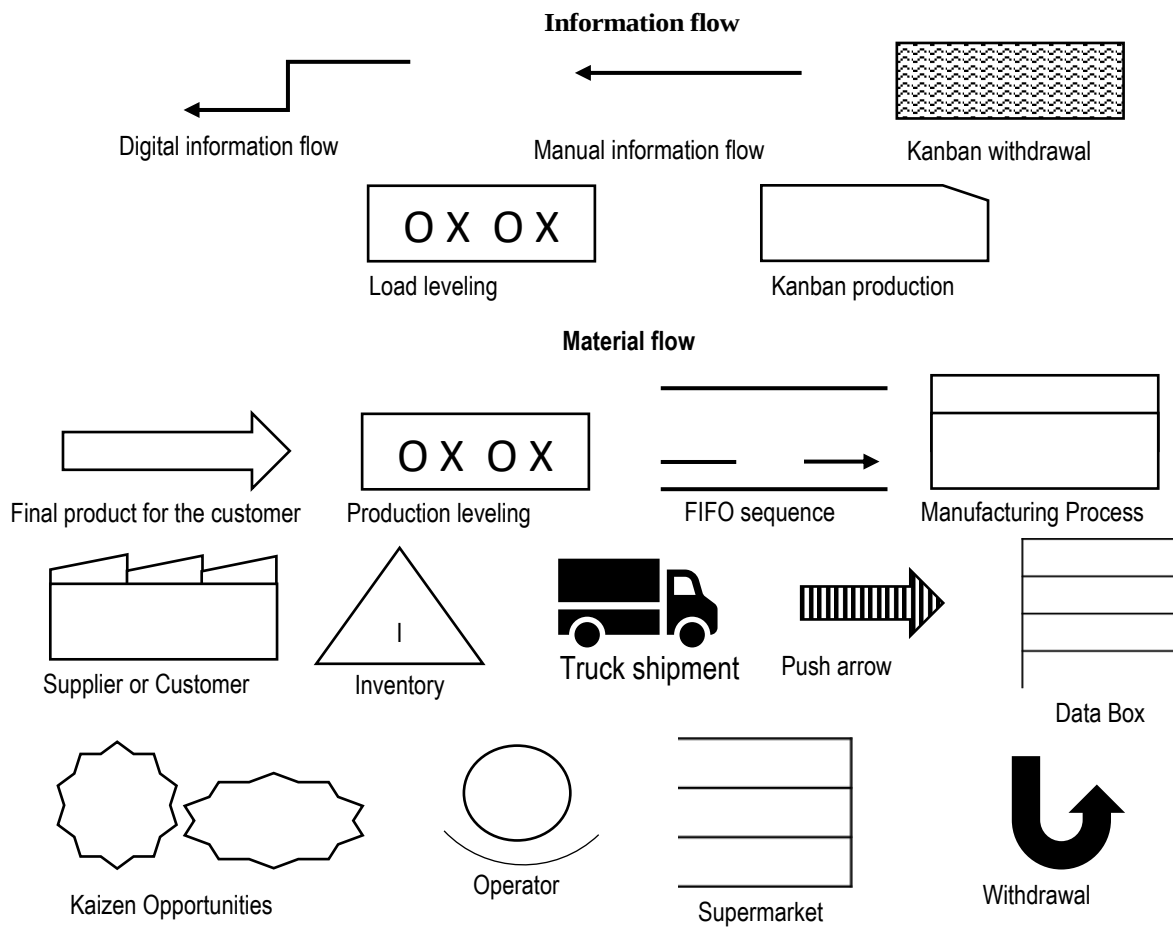
According to Liker (2007b), this visit usually begins with the receipt of the raw material, followed by the first value-added process, following the material through its process of transformation. It is observed, in the case presented, that the character Luiz followed this procedure: "Starting at the yard, Luiz accompanied a truck unloading logs, the main raw material for production, acquired monthly from reforestation companies and small producers". In this first stage of the production process, it was possible to identify not only the beginning of the process, but also the main raw material of the company, the suppliers, and the frequency of purchases. Added to the information from the first question, the pull system and weekly production planning, it is possible to close the first quadrant of the VSM, the flow of information, as shown in Figure 12.

By following Luiz's visit to the factory, it can be identified that the company's material flow comprises the following steps: yard/steaming, lathe, dryer, assembly, press, finishing and shipping. In VSM, "processes are represented as boxes. The arrows connect the boxes" (Liker, 2007a, p. 267), in this way, it is possible to close the second quadrant of the VSM, the material flow, as illustrated in Figure 12. The information flow must be connected to the material flow also by arrows, representing the pull system of the company. On the other hand, priority orders were also scored in the first question, represented by dotted arrows in the VSM in Figure 12.

The leader's objective in visiting the production process was not only to understand and map the flow, but to bring about an intervention and lead the employees themselves to feel dissatisfied with the losses in the system (Liker, 2007b). In the case presented, this position can be seen in the dialogue: "We want to detect whether there is any wastage of raw material. Do you think it is possible for us to make some adjustments to the lathe? I believe so. I can run some tests." It is considered that operators are enthusiastic about having their opinions listened to, and because they have a good knowledge of their processes, they can propose improvements, making the mapping even more complete. Opportunities for improvement perceived by the administrator and employees must be indicated on the map in their respective value stages, by ten-point stars, as shown in Figure 12.

According to Liker (2007b), a third quadrant could be added, to measure the Lead Time of the flow of materials and information and, thus, get an idea of the time it takes for the order to reach the end of the process. The idea would be to streamline the steps and reduce this amount of time. However, the current dilemma is related to the waste generated throughout the production process, so it focused on describing the flow of materials and information. Students can try to map this last quadrant, but the case does not present data to support this stage, because the company does not have records from 2015. On the other hand, it was considered that for the target audience and for educational purposes, the mapping focused on waste and value streams would be suitable for illustration purposes.

Figure 11.
VSM symbols

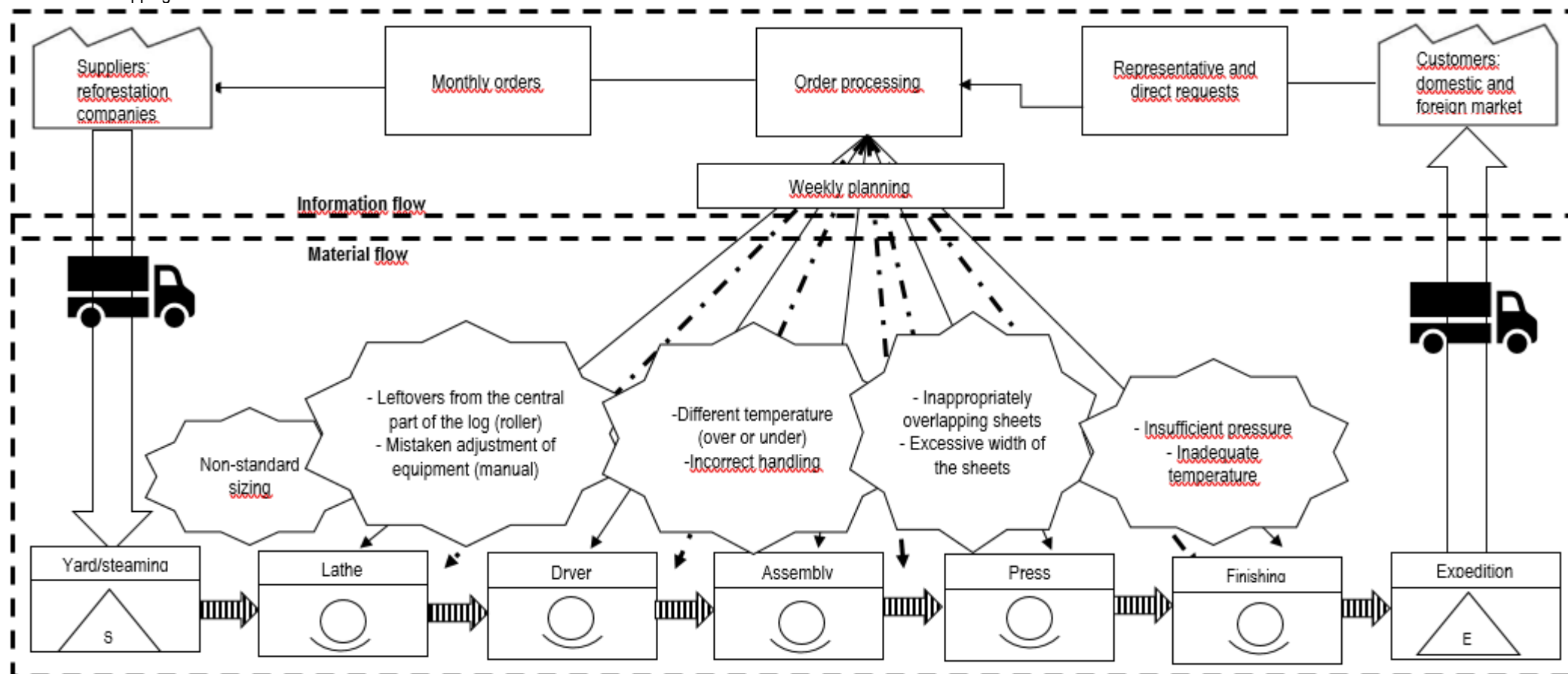


Source: Adapted from Dennis (2008, p. 104).

In the test, only two groups failed to draw the VSM, but they listed all processes correctly. It was observed that because the class was held online, mapping was more complex than it would have been in person, due to the students' internet connections and the lack of ability to create the maps remotely, taking more time to draw.

...

Figure 12.
Value stream mapping



Source: Prepared by the authors.

Question 3: What other ongoing improvement tools of the Lean Manufacturing philosophy are suggested for managers?

The Lean philosophy is not just suitable when searching for areas of wastage; it can also be used as a strategic tool based on quality methods and tools, as long as they are focused on operational excellence and customer focus (Dennis, 2008; Liker 2007a). As we have seen, over the years, many quality tools have been added to the Lean philosophy, in addition to the production house, **Figure 13** describes these practices:

Figure 13.

Practices and Characteristics Associated with Lean Production

Practices and Characteristics	Description
Ongoing improvement	Aimed at ongoing incremental improvement in quality, cost, delivery and design.
Just in Time	Aimed at continuous flow of production.
Kanban	Card system to create a drawn flow.
Supplier development/collaboration	Activities aimed at developing relationships with suppliers in order to obtain their collaboration.
5S	A form of visual management designed to reduce clutter and inefficiency in productive and administrative environments.
Total productive maintenance	The objective is to improve the reliability and capacity of the machines through periodic maintenance regimes.
Batch reduction/stock reduction	Formation of small production batches to reduce work-in-process and increase variety.
Multifunctional employee/involvement in the process	Development of employees' skills and encouragement of autonomy to avoid failures throughout the process.
Improvement Circles - Kaizen	Promotion of systematic discussions between operators and managers in order to promote continuous incremental improvement.

Source: Adapted from Jabbour, Teixeira, Freitas and Jabbour (2013, p. 845).

For Liker (2007b), when preparing the VSM, it is necessary to keep in mind the desired future situation. In the context presented, this goal is highlighted in the excerpt: "The two began to study the case, analyzing documents, observing the bottlenecks, and prepared a report that accounted for an annual loss of R\$ 500 thousand which, if avoided, could revert the value to the company's cash". This vision of wastage reduction, considering the type of finite raw material of the company and, together with financial gains, is seen by Liker (2007b) as one of the lessons to be learned during the waste reduction process. On the other hand, to enter the ongoing improvement cycle of the Lean philosophy, an action plan must be created to adjust the notes made during Luiz's visit to the factory, namely:

- **Logs:** non-standard sizing.
- **Lathe:** leftovers from the central part of the log (roller); wrong adjustment of equipment (manual).
- **Drying:** different temperatures (too much or too little); incorrect handling.
- **Assembly:** Sheets not overlapping properly; excess width of the sheets.
- **Pressing:** insufficient pressure; inappropriate temperature.

Comparing the results of the VSM and the described practices, it is seen that the company, initially, can take action in order to promote greater collaboration with the supplier, especially with regard to the dimensioning and quality of the material sent. The process requires total productive maintenance for machine adjustments, observed in the lathe, drying and pressing stages, in addition to continuing to invest in employee training.

In the test, we asked the groups to classify the type of waste mapped (transport, stock, **movement**, **waiting**, overproduction, **over-processing**, **rework** and **intellectual**). Those highlighted were the ones most cited, and the proposals were Kaizen, Poka Yoke, maintenance, training, 5S, time adjustment. In general, the groups were more concerned with detailing the problem than with the proposed solution.

Outcome of the case

Always attentive, the Wood's Valley sawmill is focused on ongoing improvement, which is why it took actions to reduce, as much as possible, the sources of wastage identified in 2015:

- Regulation and adjustments of all machinery and acquisition of more modern machines.
- Continual training of teams, routine monitoring of work activities carried out at the factory, as well raising awareness among employees regarding the need for standardization and taking care to avoid production wastage.
- Management of suppliers (requirement for the standard of raw material supplied).

Through these measures, significant improvements were obtained in the production process and waste was reduced. However, the company is constantly seeking to improve its processes. In addition, it has grown and has been showing positive results, even in the face of economic difficulties, both in the domestic and foreign markets. This demonstrates that the company is well managed and has had repeated successes. Figure 14 below presents the key facts in the company's last four years.

Figure 14.

Updated chronology

Year	Event
2017	Planning for the opening and start of production at the planalto catarinense (Santa Catarina highland) branch.
2018	The dynamic world market supported the company to pay off the subsidiary's investments and strengthen its working capital.
2019	Significant shrinkage in the world market, drop in prices, up to 40%. Partnership with a North American company.
2020	Good results with the American partner. Land acquisition and reforestation.

Source: Prepared by the authors.

In 2017, the Wood's Valley sawmill planned to open a branch in a city on the planalto catarinense, or Santa Catarina highlands region, in order to increase its production and to be able to serve customers with greater volume, mainly in exports. Throughout the year, it worked on purchasing machinery and defining the location and volume to be produced. The choice of location for the new branch was due to the proximity of wood suppliers, the main raw material used in the manufacture of plywood. At the branch, activities of the lamination and drying sector began at the end of 2017, with major challenges, as it is a region with a different workforce and culture from that of the head office. The sawmill invested approximately R\$ 8 million in opening the branch and the funds were all its own, and the balance was paid off in the first year of activity.

In 2018, it was noticed that there was a reduction in reforestation planting by investors (doctors, lawyers and rural producers), signaling a lack of the main raw material, wood, in the future. The company had purchased some land in previous years, but this was not sufficient to match its consumption. It currently consumes around 8 thousand tons/month of wood (pine and eucalyptus logs), which corresponds to approximately 13 hectares of species per month. Based on these figures, it drew up a plan for the company to become at least, 70% self-sufficient in terms of its raw material. For an initial 18-year plan, the amount of land needed would be 2,000 hectares.

In 2019, the company expanded its business, starting a partnership with an American company, whose main client is the US Armed Forces. This company had a 50% share in the investments. In 2020, it saw the results of that partnership, and is now looking to expand this business. To meet this demand, the sawmill implemented a major change: it started to buy plywood and sawn wood from other suppliers in the region. It is also advancing towards its goal of self-sufficiency, with the purchase of some land and reforestation, comprising around 10% of the planned goal.

By the end of 2020, the Wood's Valley sawmill had achieved approximately 25% self-sufficiency in relation to its established goal. One of the company's rules is to distribute 1/3 of the profits obtained and to invest the other 2/3 on updating its industrial park and achieving its goal of self-sufficiency. The company currently has 220 employees and a monthly turnover of around R\$ 5 million. It produces 3,600m³ per month, of which 65% is exported to the foreign market. The other 35% of plywood production is sold on the domestic market, in the states of GO (Goiás), ES (Espírito Santo), RJ (Rio de Janeiro), SP (São Paulo), RS (Rio Grande do Sul) and SC (Santa Catarina), where it is used for the production of furniture and in civil construction.

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