HUMAN LIMITATIONS ON WASTE DETECTION: AN EXPERIMENT

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ABSTRACT

Production Waste, or in other words, the search for its elimination, has been the target of most important production philosophies. Mass production success was based on the drastic cost reduction caused by the elimination of many forms of waste. Lean production went even deeper by pursuing the elimination of more forms of waste. Waste elimination plays a key role in production performance and this paper intends to contribute not only to a deeper understanding of production waste but mainly to the issue of the natural human limitations to detect it. Waste detection can be performed from two different angles, either from the search for non-value adding activities, or from the focus on value adding activities. Aligned with what some experts say and from the experiment presented on this paper we tend to believe that when we focus our attention on value adding activities and eliminate everything else the results are better. This paper also shows that people are normally 'influenced' by existing production practices and therefore their ability is conditioned to detect existing forms of waste. On this study we carried out experiments where industrial engineering and management students looked for production waste under those two different approaches and the results are as expected.

INTRODUCTION

The impact of Lean Production in world's economy during the end of the twentieth century can be easily compared with the impact obtained from Mass Production during the beginning of the same century. Both lean production and mass production are, beyond doubt, the major milestones in the history of industrial management. Both concepts were created in the car industry; mass production associated with the assembly line concept was developed in the Ford Company while lean production was developed by Toyota Motor Company. The concept of lean production was originally developed by Taichi Ohno during the decade of 1950 under the name of Toyota Production System (Ohno, 1998). This way of organizing and managing production was later coined as Lean Production by a research group from the Massachusetts Institute of Technology (Womack, Jones, & Roos, 1990). This research group was involved in a 5-million-dollar and 5-year-long project studying the car industry all over the world during the 1980s.

Lean production can be seen as an evolution of mass production and one of the similarities is the focus on waste reduction. Lean manufacturing puts its main focus on clarifying the difference between activities contributing to adding value to the product and activities that do not add value to the product. Any effort, time or resource used in activities that do not add value to the product is considered waste ('Muda' in Japanese). The continuous identification of waste and its elimination is the mechanism for continuous improvement, being a key factor in lean production environments. The idea is that any waste that is eliminated results in production performance improvements and therefore is a step towards higher competitiveness.

Factories as well as offices are filled up with waste everywhere but this is not always easy to identify or eliminate. Many forms of waste are not identified by everyone as such and to make things even more complicated, some authors and experts classify some waste as "necessary waste". People with different experiences, backgrounds, and production culture; do not always agree on labeling some activities as waste and it is also true that some waste could never be identified at all because it simply wouldn't be noticed. Even the very same person, looking at the same production problem from different angles would identify different forms of waste.

This paper intends to show that one only person analyzing the same production problem with different information would identify different forms of waste. Another interesting feature is that different results are obtained dependent on our focusing the attention on non-adding value activities or on value adding activities.

WASTE

Waste is usually defined as anything that does not add value to the product; in other words, anything that adds cost to the product but which the customer does not pay for. The value of a product can then only be defined by the ultimate customer [3]. Waste is therefore intimately connected to value and a good way of identifying waste is by recognizing which part of the process is actually adding value to the products.

Another way of understanding waste is by looking at the nature of the operations performed in production systems. Everything that is performed on a product and does not result in any physical or chemical changes can be considered waste (note that having physical or chemical changes doesn't necessary means adding value either). Any operation that does not change anything on the product does not add value (Some may not agree but under this definition inspection is waste). On the other hand, some operations resulting in real changes on the product may not add value and therefore are waste. This type of waste is classified as over-processing waste.

Forms of waste are classically classified in seven types (Ohno, 1998): waste of overproduction, waste of time on hand (waiting), waste of transportation, waste of processing itself, waste of stock on hand (inventory), waste of movement, and waste of making defective products. It is important to point out that waste of overproduction plays a key role in production waste since it leads to all the other types (Kobayashi, 1995). Incluir aqui referencia apresentando a Relação com outros desperdicios The detailed description of each type is not among the aims of this paper; nevertheless, the clear understanding of those forms of waste is vital for the understanding of the whole paper.

All these forms of waste are to some degree (most of the times to a large degree) presented in general industries and offices. If we look at waste from the throughput time perspective we realize how negative the impact of waste on production is. We are stressing the throughput time perspective because for some authors it is the key production performance indicator (Suri, 1998). Looking then from that angle we realize that only about 5% of the throughput time in a production system is actually used in operations that add value to the products (Productivity Press Development Team, 1998) but in offices that percentage decreases to about 1% (Hines & Taylor, 2000). Most of the time products undergo operations that do not increase their value or are just waiting for something. To be more accurate, we can say that products are kept most of the time waiting for something. In offices, documents are kept most of their throughput time waiting for something to happen (waiting to be signed, to be reviewed, to be analyzed, to be evaluated, and so on). In factories parts wait in queues to be processed, to be transported, to be inspected, and so on. If we look at waste from the cost perspective we can say that the improvement on financial performance changes significantly as soon as waste starts being eliminated

When I try to make people understand waste, a list of traditional questions usually arises: 'how can I consider transport as waste if I really need to move the products from one machine to the next or from the warehouse to the assembly line?'; 'how come the time I spend on setting up the machine is waste?'; 'when I inspect the quality of the product I am actually adding value to the product since that product is declared as good; how can that work be waste?'. Apart from this type of questions there are other more complicated problems. The idea of production in batches is difficult to be identified as waste because producing in batches is so natural and obvious that most people would never regard it as waste.

Some authors propose the distinction between necessary waste and non-necessary waste (Hines & Taylor, 2000). According to them, non-necessary waste is the one that is possible to remove according to the circumstances while necessary waste cannot be removed unless the existing supply process is radically changed. This distinction is acceptable and understandable but there is a small danger associated with it. Many managers may stop chasing waste elimination as long as they label most of their existing production waste as necessary. I do not think this distinction is necessary and I am quite confident that it does not make things easier.

One important issue in this paper is: since waste is everywhere in the factory, where should we start from? How can we be effective in identifying and reducing waste? To answer those questions we can say that there are at least two main approaches: (1) approaches centered on detecting non-value adding activities and (2) approaches centered on value adding activities.

The approaches centered on non-value adding activities put all effort into identifying activities on the shop floor that do not add value to products. One straight forward way of doing so is going around the factory or office trying to find forms of waste and then trying to eliminate it. This is not a very effective way to go lean. A good though not easy approach is building a culture of continuous improvement among the workers and middle managers. On this approach workers are continuously looking for forms of waste on their work area and proposing solutions to its elimination. Creating such a system is not easy at all, for it requires energy, patience, persistence and many adjustments. A more systematic and effective technique for waste identification is the technique known as “Treasure Map” (Kobayashi, 1995). This technique uses the principles of work sampling studies to identify the areas on the shop floor where more waste occurs. The first area to be focused on by waste reduction actions would be the area where more waste is identified. Detecting areas with large quantities of waste is comparable to finding a treasure because of the money you can save once that waste is eliminated.

The approaches centered on value adding activities deal with the problem from a complete different angle. Instead of trying to find waste and eliminate it, what many experts suggest is that you identify the necessary adding value operation for a product or family of products and then eliminate all the remaining operations. A technique that can be very helpful for that purpose is the Value Stream Mapping (Jones & Womack, 2002). In spite of some limitations, this technique makes a clear distinction between adding value and not-adding value operations as well as the time spent on each one throughout the production system. The use of this technique does not find for you solutions to reduce waste, it only helps to clarify the value adding activities on the value stream.

We can say that the improvements on waste reduction go through three steps: (1) understanding the concept of waste; (2) identifying forms of waste on the shop floor; and (3) eliminating or reducing waste. The identification of waste is the key factor in the process of waste reduction. As Taiichi Ohno once said: “Eliminating manufacturing waste is not the problem, identifying it is”. I agree with the power of such statement but, in some cases, the way of eliminating waste is known but its financial viability is not clear.

This paper intends to show that people can be easily conditioned by the existing practices on the shop floor and therefore be unable to detect several forms of waste. On the set of experiences reported here, we can also see the results achieved by the two main approaches for waste identification: (1) the approach centered on the detection of non-value adding activities and (2) the approach centered on value adding activities.

THE EXPERIMENTS

The ability of a person to perceive production waste is strongly dependent on which production culture the person is involved in ~~with~~ as well as on how much the person is informed or experienced of the concept of waste. Workers, supervisors and managers in traditional production environments are so used to their production practices that they are not able to see many forms of waste present everyday around them.

The experiences presented here are the result of an interesting finding occurred during the introduction of Lean Production principles to engineering students at School of Engineering of Minho University. A common behavior pattern has been perceived during a production game that has been

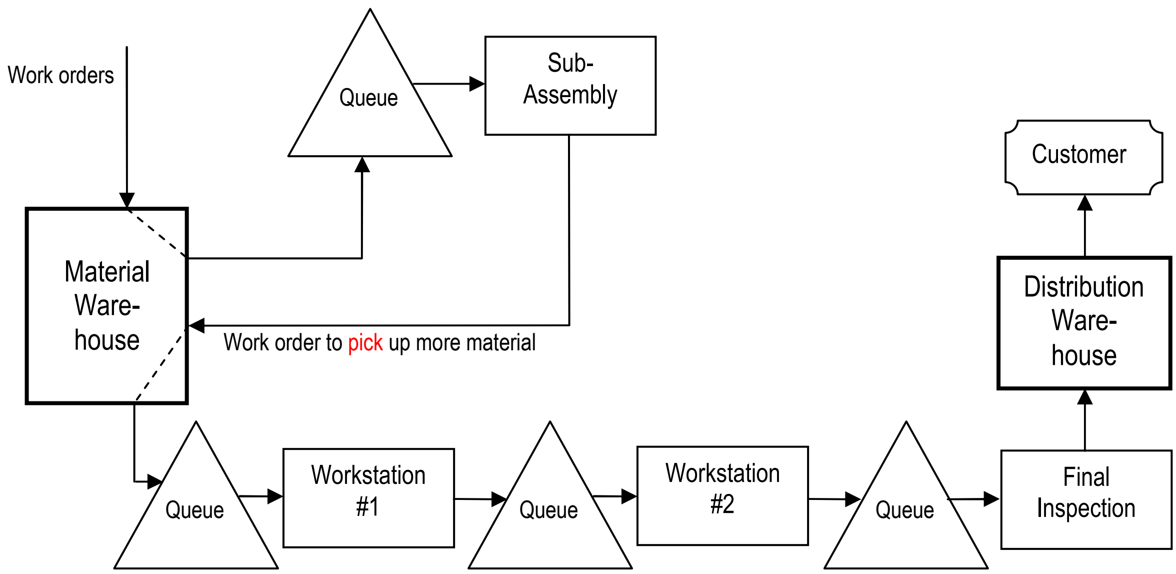

Figure 1. Production Systems Flow Overview.

taking place every semester for the last 5 years. These findings made me understand some of our limitations in understanding production waste as well as understanding how much we are conditioned by our own intuition.

Description of the production game

In (?)One of the first lectures(?) on lean production a basic production system is set up in the classroom showing two alternative ~~production~~ approaches for the same production problem: the traditional mass production approach and the lean production approach. We start with the traditional mass production approach (see figure 1), setting up the warehouses, workplaces, buffers, and so on and making ~~the~~ students participate actively in the operations of that almost real production environment during some time to feel its dynamics. The students are then asked to measure the performance of the system, identify forms of waste~~,~~ and ~~to~~ propose improvements. The production system is then modified into a lean production form and once again students are involved in the operations for the same amount of time they did before so that they can fell the differences in both approaches.

The students needed in the game to make the production run are the following: two acting as suppliers, six as workers, one as quality controller, one as production manager, and a last one acting as customer. As there are usually more students than necessary to run this 'factory', some of them ~~are~~ just observe while they take their own notes on paper. These observers need to pay attention as they will be asked to propose improvements.

In this production system, four different types of products can be assembled and a Takt Time of 20 seconds is assumed for market demand. Once the production is set, the person acting as customer places an order every 20 seconds. They can order one of the four available types of products chosen at random. If that product is already assembled it is considered to be on time; otherwise it would be considered a late delivery. We normally perform a production run for 5 minutes which means that the customer actually places 15 orders. The production is managed based on production orders, using batches of 5 products in a push production manner, following the philosophy MRP production way. The 'factory' is full of products everywhere and everybody is quite busy. At least one workplace is clearly identified as bottleneck and sometimes the student acting as production manager addresses somebody or himself to help that 'worker'.

Once the production run is finished I ask the students to measure the performance of the existing production system. The main performance indicators are traditionally: productivity, customer satisfaction, cycle time, labor utilization, WIP, throughput time, and number of tables utilized. The students are then asked to identify waste and propose improvements. They identify some forms of waste such as transport, inventory, and waiting. Proposed solutions vary from class to class but a common proposal is that ~~to put~~ more workers should be used considering that the worker at the bottleneck is not able to deal with the queue that piles up just before his(?) workplace. I explain that this solution is not ~~a~~ good ~~solution~~ because it only causes performance to be even worse. I also explain that the capacity of the bottleneck that they detect is higher than the capacity needed to the existing demand.

After some discussion I divide the class in groups of 4 or 5 students and I give them the task of proposing improvements to the existing production system and suggest a solution producing less waste. Once they finish their suggestions, each group runs the system and we measure its performance. Most groups end up with some improvements on production performance, usually solutions such as improving the layout, reducing transport, and reducing one or two workers. Curiously students normally do not recognize that:

- Batches may not be necessary,
- Quality controllers may not be necessary,
- Overproduction is easily avoidable,
- Most transportation can be eliminated,
- The supervisor may not be necessary,
- The production may be pulled by demand requests,
- And so on.

These students look at the problem just as anybody else without any training in lean manufacturing, as most workers in our traditional factories and offices.

The production system is then modified into a lean production oriented approach (see figure 2) where we can see many lean production practices applied: one piece-flow, pull production using kanban, milk run, production cells, new relationship with suppliers, etc. In this lean manufacturing type production run we use only 3 workers, the supplier brings the components directly into the assembling line using a two bin system, and no quality controllers are used (workers are responsible for their production quality). The concept of lot is dropped; the workers assemble the products as they are pulled by demand, one at the time. There is no need to production orders since the production is pulled by demand as you see by the chain of kanban systems in figure 2.

In this production run only 3 students are involved in the same 15 customer orders production cycle. The production runs very smoothly, in an organized, orderly and relaxed manner. A very different environment from what we have seen on the traditional approach where ~~the~~ confusion was installed. In the end ~~the~~ students are also asked to measure its performance and compare it with the performance obtained on the previous production approach.

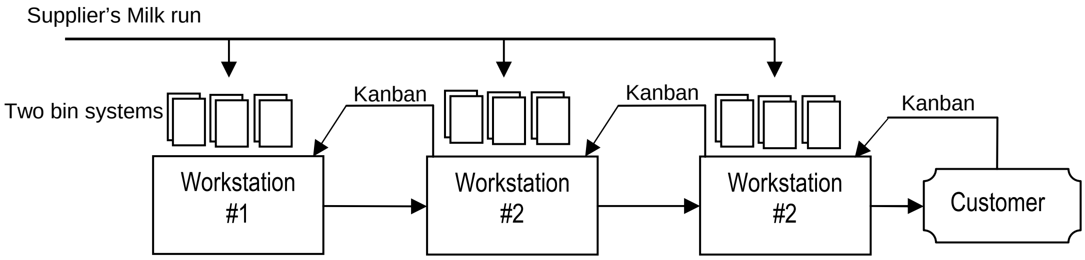

Figure 2. Production Systems (lean version).

With this approach we only use 3 workers producing (selling) the same amount of products during the same time so ~~the~~ productivity ~~was~~ increased dramatically. Other performance indicators such as WIP, throughput time, and space utilized were also drastically reduced.

An Interesting Experience

In one of the lectures where I was supposed to play the production game described earlier I had to do something different. On that day the number of students in the classroom was a bit too large (a bit more than 60 students) and that was a problem to the production run. I know that if there are too many students just observing, not actively involved in the game, they get a bit noisy and distracted, and I had to find a solution to avoid that.

I divided the class in two groups of students in two separate classrooms. With one of the groups (let's call them ~~as~~ group A) I performed the production game as described earlier in this article. With the other group (let's call them ~~as~~ group B) I just gave them the description (drawings, bills of materials, as well as prototypes) of the products they had to assemble and the type of demand (in terms of *takt time*). All ~~of~~ that information is exactly the same ~~information~~ given at the production game. The job of students from group B, working in teams of 5 or 6 members, was to build from scratch a production system able to respond to the *Takt Time* of 20 seconds with random customer orders, as in the game. They had to test different ways of assembling the products, ~~they had to~~ measure assembly operation times, assume inventory policies, number of workstations, batch sizes, etc. in order to meet customer demand, and present a solution to be tested in the classroom.

Group A (the group that was involved in the production run of the traditional factory) as in previous experiments came up with the same type of comments and solutions. Very little performance improvements were achieved with their proposals. Although they detected several forms of waste, the solutions to eliminate them were in most cases not achieved. I consider that the student teams from this group actually approached the problem from the point of view of identification of production waste, focusing their attention on non-value adding activities and trying to find solutions to eliminate it. They apparently followed the approach described earlier in this paper as 'centered on the detection of non-value adding activities' ~~approach~~.

Amazingly the teams from group B came up with solutions a lot more efficient than the ones developed by teams from group A. Since they were not "influenced" by any existing production practice, they had their focus on value adding activities and the result of their production system design was a lot less messy and with a lot less production waste than the solution developed by group A teams.

THE RESULTS

The results obtained in the casual experience described earlier in this paper, pointed out something that was expectable although I was not expecting to see it so clearly before my eyes. In the first place I didn't expect any difference at all in the performance achieved by type A and type B teams. I just created those two groups (group A playing the production game and group B not playing the production game) because there wasn't enough material to play the game in two separate rooms. When I saw the differences in the results I was amazed and everything was immediately clear in my head. The students from group A, the ones that were involved with the traditional production approach (see figure 1), were really conditioned by the existing production culture and therefore ~~they~~ were only able to perform little improvements in the production performance. Once they take the existing production culture and practices as reference they tend to focus their attention on the elimination of the existing non-value added activities. Since these non-value added activities are the natural result of the applied production practices, they make perfect sense for the people involved. These ~~people involved~~ have perfectly valid arguments to explain the existence and the need of such production activities, which is one of the reasons why waste elimination can be so difficult. Only the most absurd non-value added activities are then eliminated resulting in poor performance improvements. Examples of practices that are not questioned by people without lean manufacturing training are the use of large production lots, process oriented layouts and inventory.

On the other hand, students from group B did not have any contact with a production solution to that production problem. They had to look at the problem from a very wide open point of view without any type of constraints or reference solutions. Since the only information they had was the product description, production demand, and needed operations, they would focus their attention only on the value added activities (needed operations), building the production solution around that. This type of approach may be the reason why in general the production solutions proposed by student teams from group B result in very good overall performance.

Tab. 1. Comparison of production performance results.

Perform. Indicators	Traditional practices	Group A (Common values)	Group B (Common values)	Lean Solution
Production time	5 min	5 min	5 min	5 min
Products sold	15	15	15	15
Cycle time	20 sec	20 sec	20 sec	20 sec
People involved	8	6	4	3
Throughput (p/h)	180	180	180	180
Productivity (p/man.h)	22	30	45	60
WIP	90	35	15	8
Throughput time	30 min	11.6 min	5 min	2,7 min

Legend:
(p/h) – parts per hour;
(p/man.h) – parts per person per hour;
WIP – (Work In Process) – Number of parts being processed.

Table 1 shows the production performance results obtained from different production runs. The first column is related to the production performance achieved by the production proposal following traditional practices (see figure 1). This ~~production~~ proposal is based on traditional practices, maybe a bit exaggerated to show the idea. The second column presents the average performance indicators obtained by production proposals developed by student teams that had contact with the traditional approach. The commonly obtained gains are not very significant. These students have difficulties in questioning some practices that they accept as standard such as batch production, quality inspection separated from production, push production, etc… It must be pointed out that these student teams generally start with proposals that actually worsen the performance, as ~~it was shown~~ previously explained in this paper. After some clarifications and discussion on production waste they are then organized in teams to generate a better solution than the existing one. The improvements suggested by this kind of students are based on small changes in production details and never ~~based~~ on deep changes of production practices.

In the third column we can see the results obtained by the student teams that did not have any contact with any production solution. They normally develop a production system based on demand and product requirements. Sometimes they forget small detailed requirements(?) but in general they come up with very effective solutions that generate very good production performance.

Finally, I build the lean manufacturing predefined solution, using *kanban* systems, two-bin systems for component supply, as well as other lean practices. This solution is normally the best of them as you can see on table 1.

CONCLUSIONS

Improving production performance through waste reduction or elimination can be done either with focus on value adding or ~~with focus~~ on non-value adding activities. When we are improving an existing production solution we tend to be conditioned by the existing practices and some forms of waste cannot be detected. Even when they are detected, solutions to its elimination are difficult to find since we are conditioned by existing practices. In these cases we tend to focus our attention on non-value adding activities. On the other hand, if we are not exposed to any existing production solution we tend to focus our attention on value adding activities and achieve better production performance. This paper shows an experiment where some teams of students were exposed to an existing production solution while some other groups were not. All teams had the task of developing the best possible solution in terms of production performance. The teams not exposed to existing solution performed a lot better than the other ones. As far as I'm concerned, the reason for these results is that the teams exposed to existing solution focused their attention on non-value adding activities while the others ~~teams~~ put their focus on value adding activities. I conclude that, in the process of waste elimination, focusing attention on non-value adding activities is less effective that focusing attention on value adding activities. In order to do it in a systematic and organized approach, we can use the Value Stream Mapping techniques.

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