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Simulation Game for Lean Leadership – Shopfloor Management combined with Accounting for Lean

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Abstract

The Technology Centre PULS (Production and Logistics Systems) operates a learning factory for application-related research and education in the areas of Lean Production, Accounting for Lean as well as Industry 4.0. The main didactic approach for teaching and training is simulation games. Lean Production is accepted as the benchmark for a high efficient production. Nevertheless, the results of Lean transformations often lack behind the expectations. Experts consider that Lean initiatives need to enlarge their focus. Therefore, the simulation game described in this paper points out the need for shopfloor management in combination with the new field of Accounting for Lean.

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Keywords: learning factory, simulation game, shopfloor management, Accounting for Lean, Lean Production

1. Introduction

The PULS Technology Centre for Production and Logistics Systems operates a Lean learning factory. The highlight is a 900 m² production area with state of the art infrastructure for manufacturing and assembly according to Lean principles. It is designed to mainly train the methods as well as the principles of Lean Production and Lean Logistics in a realistic learning environment to students as well as practitioners from international companies. In general, the

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technology centre as a more realistic simulation game environment gives the participants a connection point with their own workplace.

Simulation games in learning factories have a high level of relatedness to reality. This increases e.g. the effort for developing and performing a simulation game. Therefore, it should be evaluated if the circumstances of the intended learning scenario support the decision for a realistic learning environment [1]. In the case of the simulation game for teaching Lean Leadership, the authors have the opinion that the advantages justify the higher effort.

This article describes how an existing Lean simulation game was extended with two additional modules. The first one is an accounting module to show the need for a Lean conformable accounting system. The second module explains the necessity for an adequate shopfloor management system.

2. Problem statement: Enlargement of Lean initiative in companies

The principles and methods of Lean Production are accepted worldwide as the benchmark for a highly efficient and competitive production [2–4]. Nevertheless, most companies still do not realize the full potential of Lean. The results of a Lean transformation often lag behind the management's expectations [3]. For sustainable bottom line effects, experts suggest that Lean initiatives need to enlarge their limited focus from production and logistics to implementing an integrated comprehensible Lean Management System [2, 4]. Traditional standard absorption costing, as an essential part of management systems, is recognized as a barrier to a sustainable Lean transformation [5].

The developing field of Accounting for Lean (AfL) evolved to overcome these obstacles and to provide information, which is congruent with Lean Thinking and actively supporting the Lean journey. Managers and controllers need to be aware of the problems of traditional accounting in Lean environments as well as accounting alternatives to support Lean.

A great challenge in implementing an AfL system is "the lack of education and understanding of what is an appropriate methodology to account for Lean" [6]. Traditional accounting education is focused on external financial accounting and does not expose students to Lean Management. The barriers to AfL in academia seem bigger than the barriers in companies [7]. To achieve a holistic management system, the top-down approach of accounting needs to be enlarged by the bottom-up view of the shopfloor. The implementation of a shopfloor management system is an important step for lean leadership. A common management style in companies can be described as "management by remote control". This approach is based on reports, ERP systems and so on. The result of that is the management's focus on a so called "supposed reality". With that, the question rises, if manager really know their processes and how effective they lead [8]?

The lean philosophy suggests a different management style called "management by established facts (Genchi-Genbutsu)". The main difference in this approach is, that the managers verify problems or progress personally on the shopfloor. The result of that is an extreme reference to reality of managers where they really know their processes and lead through example [8].

3. Necessity for new simulation game

As the result of the problem statement, it is necessary to teach Accounting for Lean and shopfloor management combined as two parts of a holistic Lean Leadership concept. Accounting for Lean focuses result indicators in a production company, e.g. such as production output, utilization of machines, turnover and profits. To counter that top-down approach, the collection and reasonable use of performance indicators from the shopfloor is an important second aspect of teaching Lean Leadership.

Adequate programs for educating Lean Leadership must be developed to close this gap and support a holistic Lean approach. Simulation games in learning factories are an excellent way of teaching Lean principles, methods of AfL (result indicators) as well as shop floor management (performance indicators) [9].

Therefore, the Technology Centre PULS (Production and Logistics) developed a simulation game for Lean Leadership in its learning factory to teach the necessary unity of

- production system,
- organisational structure and
- accounting system

for successful Lean transformations.

4. Simulation Game for Lean Leadership – Shopfloor Management combined with Accounting for Lean

Besides the general advantages of simulation games in learning factories, the learning content in this case makes the higher effort necessary. There are numerous successful Lean simulation games taking place in class rooms. Nevertheless, the authors have the opinion, that a learning factory promises the best learning outcome for teaching content about production systems in connection with organizational and accounting issues.

4.1. Classification and main learning content of the simulation game "Lean Leadership"

The main didactic training tool in this learning factory is the simulation game "From Job Shop Production to One-Piece-Flow" [10] [11]. This simulation game is designed as a closed scenario multistage game. Since the target group for this game are master students and management staff, the level of complexity and interdisciplinary content is rather high. The game set is the assembly line of a company producing logistics trolleys. Eight to twelve participants assemble as one group real trolleys in two types of production systems. The participants play different roles which are assigned at the beginning are kept until the end of the game.

The main learning contents of the simulation game are

- Differences between a mass production system and a lean production system
- Lean principles in production, logistics and accounting / controlling
- Difference between traditional accounting and AfL in a Lean environment
- Necessity of shopfloor management as part of a Lean Leadership concept
- Advantages of Lean Leadership methods
- Necessary unity of production system, organisational structure and accounting system for successful Lean transformations.

With respect to the target groups and the complex and interdisciplinary learning content of this simulation game, high demands are applied when it comes to the instructor of this game [12]. The success of a simulation game in general highly depends on the qualities of the instructor. Especially the AfL learning content is fairly new and is expected to stimulate a controversial discussion during the debriefing sessions and the theory parts. Therefore, it is crucial for the success of this simulation game, that the instructor

- has a profound understanding about the learning content,
- knows about the potential discussion topics,
- and makes a professional impression on the participants by having the game under control at all times.

4.2. General structure and course of the simulation game

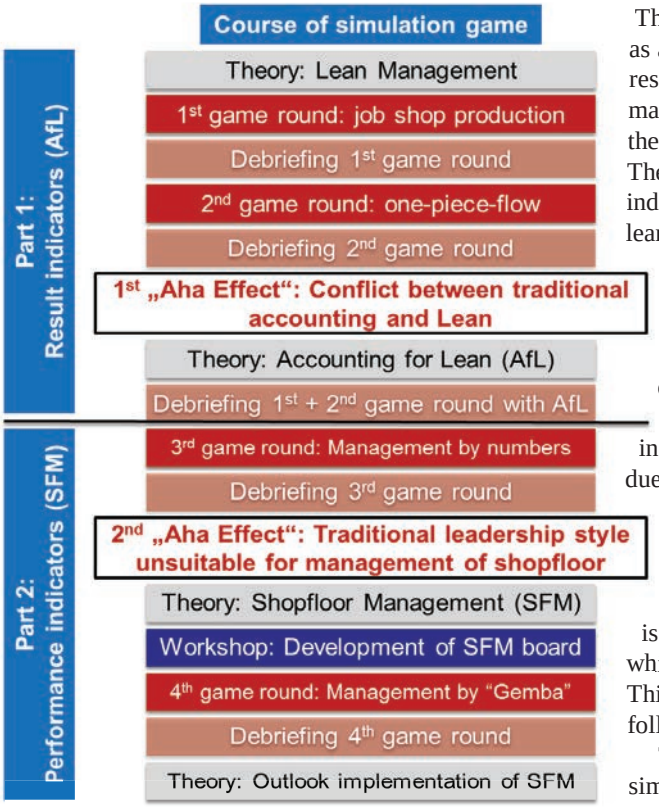

Figure 1: Course of simulation game following [10]

The simulation game for Lean Leadership is a designed as a two-day training. On day one, the focus will be on result indicators as part of Accounting for Lean. The main learning target is that the participants recognize the conflict between traditional accounting and Lean. The second day lies the attention on performance indicators of the shopfloor management. Participants learn in this part, that traditional leadership styles are unsuitable for the management of the shopfloor.

The simulation game is performed on the shop floor of the learning factory. Both production runs of part one take 12.5 minutes with a goal of ten deliveries to customers. The game time is the same in both rounds, but the production volume is different due to the creation of inventories in the first game round. In the second game round, participants are then able to fulfil the customer demand without creating inventories. In the first “Aha Effect”, it is pointed out that the overproduction of the first game round is treated favourable in traditional accounting systems, while being the most critical type of waste in Lean Thinking. Every game round of the simulation game is followed by an intensive debriefing session.

The following two chapters describe the course of the simulation game in detail. Although the explanation is cropped to the specific situation in the PULS learning factory, the structure and basic concept can be transferred to other Lean manufacturing simulations.

4.2.1. Part 1: Accounting for Lean

The **first game round (job shop production)** starts in a predefined mass production system. The trolleys are produced in a job shop production with four main steps, the pre-assembly of the steering rolls, the assembly of the whole trolley, the quality inspection and labelling as well as the packaging.

A high division of labour and different functional departments characterise the assembly process, as typical of mass production systems. The participants are encouraged to produce as much as possible because of piece rate wages. Orders are pushed through the production in a batch size of three pieces. This equates mass production thinking in economies of scales for optimising the efficiency. The design of the simulation game leads to an overproduction of trolleys because of an imbalanced production in a push-style.

A **first debriefing session** is performed after the production run at the shopfloor of the learning factory using manual and electronic multi-media whiteboards. The first debriefing-topic is the organisational and cost centre structure of the first game round. An organisational and cost centre chart is drawn on a whiteboard.

Although the game simulates a relatively small production environment, the participants realize the complexity of the system. With focus on shopfloor personnel the system consists of five departments and six cost centres. It is discussed that the division of labour and introduction of functional departments in a mass production system of HENRY FORD and FREDERICK TAYLOR causes this complexity. Afterwards participants are asked about the production process. They analyse the system in terms of TAICHI OHNO’s seven types of waste [13]. Some qualitative and quantitative

performance indicators are documented. For example, the overproduction of the first run causes an increasing stock level with about three days of inventory. The whole production system is controlled by massive stocks and causes high effort for production planning. The walking distance and path of the logistician is tracked and visualized to show the enormous effort and the low efficiency of logistics. The industrial engineers present the measured throughput times of the trolleys, which are long and instable as the consequence of the mass production run.

After this general analysis, the focus will be changed to the financial numbers. A traditional full absorption costing system is used to evaluate the financial performance with a product cost calculation and an income statement. This is done with a spreadsheet program on the shopfloor. Traditional full absorption costing is done in three steps [14]:

1. **Cost type accounting**: determination of costs incurred and systematic classification of cost types
2. **Cost centre accounting**: allocation of costs to cost centres
3. **Cost object accounting**: calculation of product costs and income statements.

In the first step, the participants discuss some basic cost accounting terms like fixed and variable costs or direct and overhead costs. In the second step - cost centre accounting - a cost distribution sheet is created step by step. It becomes obvious how complex and arbitrary the allocation of overhead costs is done in traditional accounting. The instructor will discuss some drawbacks of full absorption costing for internal decisions like the allocation of overheads in combination with raising overhead portions or the variabilization of fixed costs, which leads to poor decisions. The result of the cost centre accounting will be overhead rates for primary cost centres. These are needed for the subsequent product cost calculation. In the third step the product costs of the trolley are calculated using direct costs and the calculated overhead rates. The product costs are used in an income statement to determine the gross profit of the first game period. The income statement shows a gross profit of 164 € and a return on sales of 33 %.

After the general and financial analysis, a short brake follows where the instructor changes the layout from job shop production to flow production.

In the **second game round (one-piece-flow)** the participants run a Lean production system. Changes from the first to the second game rounds are:

- U-shaped production cell instead of job-shop layout
- Reduction of lot-size from three to one-piece-flow
- Implementation of a pull system as a replacement for of the push system
- Production according to the customer takt time of 75 seconds
- Kanban system for material replenishment including a synchronized tugger train system
- Replacement of the functional organization in favour of a value stream organization

These changes are discussed with the use of the following eight systematic first principles of Lean (takt, flow, pull, synchronization, standardisation, stability, perfection, integration) [15]. The second production run still lasts 12.5 minutes with a production goal of ten trolleys.

The **second debriefing session** starts with analysing the new organisational chart. Lean companies implement a value stream organisation, where ideally all resources are dedicated to value streams. The comparison of both organisational charts unveils, that the Lean principle integration reduces the complexity and is the basis for a holistic process-oriented organisation. Furthermore, dedicating recourses to value streams transfers overhead costs into direct costs of the value stream. The number of cost centres can be reduced due to a less complex organisation.

Table 1: Evaluation of performance indicators for both production runs

EVALUATION	job shop	one-piece-flow
stock	20 pcs	10 pcs
space requirement	100 m²	80 m²
logistics	- intransparent - enormous effort - many empty runnings	- transparent - much less effort
controlling	- enormous effort - controlling by a massive stock	- less effort and stock - 100 % delivery rate
lead times	long and instable	defined, short lead times

The Lean system of the second production run is compared to the previous mass production system using the same performance indicators. Participants realize that the Lean system enormously improved the performance indicators (see table 1).

The realisation of the pull-principle assures that production and sales volume are the same, i.e. the overproduction of the first run is avoided. After physically experiencing and discussing the benefits of the Lean production run, the financial analysis is performed using a spreadsheet software. Data about inventory and production volumes are entered. The spreadsheet shows the product costs and the gross profit of the Lean system (see table 2).

Table 2: Product costing and income statement for both production runs

Product cost calculation	round 1	round 2
material costs	30,00 €	30,00 €
direct costs pre-assembly	0,53 €	0,80 €
overhead pre-assembly (110 %)	0,59 €	0,88 €
direct costs assembly	0,53 €	0,80 €
overhead assembly (110 %)	0,59 €	0,88 €
direct costs QA	0,33 €	0,50 €
overhead QA (113 %)	0,38 €	0,57 €
direct costs packaging	0,27 €	0,40 €
overhead packaging (142 %)	0,38 €	0,57 €
product costs	**33,60 €**	**35,40 €**

Income Statement	round 1	round 2
sales	500,00 €	500,00 €
cost of sales (units sold * product cost)	336,00 €	354,00 €
gross profit	**164,00 €**	**146,00 €**
return on sales (ROS)	**33%**	**29%**

This creates a light-bulb moment for the participants. Despite improved operational performance indicators in the Lean production run, the financial results got worse. The following discussion analyses the causes for this fact. The fixed costs of the game round are allocated to the overproduced pieces in the first production run, which leads to calculative lower product costs. Traditional absorption costing defers a portion of the periods fixed costs to the inventory. The income statement does not recognize the overproduction, because the excess production volume is treated as an asset in the inventory line of the balance sheet. The underlying assumption (from mass production times) is that the capitalized inventory will be sold in the future with same profits. This assumption is not solid in a modern production reality. In consequence, overproduction is honoured by higher profits in traditional accounting. Cost of inventory or opportunity costs of capital are not considered in traditional accounting.

Accounting for Lean is defined as an “accounting process that provides accurate, timely, and understandable information to motivate the Lean transformation throughout the organization and improve decision-making, which leads to increased customer value, growth, profitability, and cash flow.” [16] Accounting for Lean utilises value stream costing for cost and profitability reporting. Key characteristics of value stream costing are discussed with the participants [16]:

- Focus on global value stream performance rather than profitability of single operations and products
- Sales and costs are recognized when incurred (turns away from accrual basis of accounting to a cash basis)
- Most non-material costs are treated as fixed costs
- Simple summary direct costing of the value stream on an actual cost basis
- Cost object and profit centre is the value stream with clearly dedicated resources
- Only few or ideally no allocation of overhead costs

- Supporting of waste elimination efforts and understandable cost information for decision-making.

Due to the value stream organisation that was implemented in the second production run, it became possible to introduce value stream costing in the simulation game.

In **the third debriefing session,** the first and second game round will be assessed with Accounting for Lean. A value stream income statement, which uses value stream costing, will be implemented. It is discussed as an alternative income statement, with a Lean conformable costing approach. The Lean production run creates a higher total profit and return on sales than the mass production run. No fixed costs are deferred to inventory. In this view inventory is seen as waste and not as an asset. Profits are generated by selling products with less total resource input and not by overproduction. In value stream costing the overproduction of the first production run creates higher material costs. All other costs are treated as fixed costs of the game period, which is more consistent with their "true nature" of cost behaviour [cf.16]. Thus, there is no difference in both production runs. This view of costs motivates behaviour that is congruent with Lean thinking.

The instructor shows, that this internal accounting system can be adjusted for external financial reporting rules. Accounting for Lean uses an internal accounting system to support the Lean strategy. The value stream statements can be used for external reporting after a few adjustments. Traditional accounting works the opposite way, because it is focused on external reporting needs and in almost all companies used for internal decision making. This paradigm shift is made clear to the participants.

After this first intensive Accounting for Lean discussion, the value stream statement for the second production run will be detailed. The participants are reminded that Lean classifies work in three categories, that are "value added", "non-value added but necessary" and "non-value added and unnecessary".

This classification is used for the introduction of new Lean-oriented cost types. The existing value stream statement will be detailed with the cost types "cost of added value", "cost of current needed waste" and "cost of waste". With that, the instructor builds a bridge to the need of a shopfloor management system which will be dealt with in detail in the second part of this simulation game.

4.2.2. Part 2: Shopfloor management

In comparison to the first part of this simulation game, the second part is a role based simulation game in addition to a workshop for developing shopfloor boards. This part starts with the **third game round (management by numbers)** where the participants are assigned to different roles in the learning factory, such as

- plant manager,
- maintenance and production manager,
- assembly manager and assembly worker,
- logistics manager and logistics worker.

The game field is now widened from the assembly line to all areas of the learning factory. Each participant receives a set of instructions according his designated role. The instructions include the role description, data and information for the specific area, the organizational chart of the company as well as the screenplay of this game round.

The plant manager and production manager are the main characters. They have the task to evaluate problems within the company and the production area. The screenplay leads them through the whole plant, equipped with information based on historic data from ERP systems. Meanwhile, the other participants play their part as instructed. The scenario of this game round is structured as follows:

1. Company misses monthly sales target, customers complain about delivery performance, inventories are decreasing
2. Production target was not achieved
3. Plant manager blames production manager for the situation and assumes, that assembly is underperforming
4. Assembly manager accuses logistics and starts creating a utilization chart
5. Production manager cannot reach the logistics manager
6. Production manager tries to analyze the issue with the help of the assembly workers

7. Maintenance tries to support the analysis and starts checking the maintenance lists
8. Production and logistics manager discuss the issue with the delivery performance
9. Logistics manager and logistics worker try to analyze the issue as well
10. Production and plant manager collect all the reports and try to find the root cause of the problem

The instructor stops the game round at this point and calls all participants for the **third debriefing session**. The main topics in this debriefing session are:

- No steering of operations in real time due to historic data
- Structure and way of communication
- Problem solving methods
- Management style of managers
- Situation of management and staff

In summary, the goal is that the participants understand, that traditional leadership styles are unsuitable for appropriate management of the shop floor.

Therefore, the next step in this simulation game is a **theory phase** about shopfloor management. To sustain the connection to the shopfloor, this session will be held as well in the learning factory. The areas of content are:

- Fundamentals of shopfloor management
- Elements of shopfloor management
- Structured daily schedule in shopfloor management
- Design of shopfloor management boards
- Communication and problem solving techniques

This theory phase is followed by **a workshop segment**, in which the participants will learn how to design shopfloor management boards. For that, empty boards are prepared together with material such as labels, signs, foils etc. The design itself can be done quick and is quite easy. The most important and difficult task at this point is the selection of the information, data and key performance indicators the participants would like to show on their boards. In order to fulfill the requirements of a holistic Lean Leadership/Management system, they need to implement result indicators from Accounting for Lean, as well as performance indicators from the shopfloor management.

The **fourth game round, the debriefing of this round and the last theory section** (see Figure 1) can be seen as one final section to conclude this simulation game. The participants have experienced the disadvantages of traditional management styles and have gained the knowledge about alternatives. With that, the instructor shows them in the fourth game round one alternative way by guiding them through a structured “standing” session with the same roles as in the third game round. They will use as well the shopfloor board they have designed. After that, the debriefing is done with the same topics as before to compare the differences. The simulation game ends with an outlook about implementing the holistic shopfloor management system in a company.

5. Conclusion

A simulation game in a learning factory is used for convincing accountants, controllers and managers, that traditional accounting concepts can be a barrier for a successful Lean transformation. In the first step, the participants realize the operational benefits of a Lean production system over a mass production system. In addition to the operational analysis, the financial performance of the mass production and the Lean production run is compared. Using traditional full absorption costing, the Lean production run seems less profitable. With the introduction of value stream costing and Lean-oriented cost types, a new value stream statement is developed that shows the participants an alternative Accounting for Lean concept. The participants get aware of the fact, that successful Lean transformations need a holistic Lean management system.

The second part of this simulation game then shows the participants the need to install a shopfloor management system as well. The most urgent reason for that is, that the right result indicators of Accounting for Lean are very important, but are still not able to manage and steer the shopfloor. For that, managers and leaders need performance

indicators from and on the shopfloor in combination with a change in the style of managing and leading. This simulation game was developed as a part of the research project Diverstiy.Impuls (16OH21019) at Landshut University of Applied Sciences.

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