

Continuous Improvement in Education: Adaptation of Kaizen Philosophy on the Example of the Student Project AGH Leanline

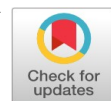
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Abstract: The current study purpose is to highlight the creation and execution of a project that will teach effectively and practically the knowledge of production engineering and will create an opportunity to acquire key competencies and attitudes on the market while still at university. This research uses the descriptive and qualitative approach. Students Research Group 'Management' runs a project which assumes optimization of production and logistic processes on the basis of identification of waste and implementation of Lean Manufacturing tools. The production line made of lego blocks - AGH LeanLine is an original undertaking of students of the AGH University of Science and Technology, adapted to practice and experience Lean methods, tools, and principles in the university environment. Each production process simulation is a Kaizen Workshop, during which the losses occurring in the basic model are defined and then eliminated from the value stream with the help of known methods of process organization. Such training is an active passage through the Plan-Do-Check-Act (PDCA) cycle, taking up and testing all the activities included in each stage. Thanks to such projects, students experience the practical application of theory and are ready to take such actions on a living organism - a production company.

Keywords: Kaizen, Lean line methodology, AGH University of Science and Technology, Japanese philosophy

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INTRODUCTION

Background and motivation

'The approaching time is the time of a mental worker who, in addition to formal education, has the ability to apply knowledge in practice and the habit of continuous learning' (Drucker, 1999).

The words spoken by Peter Drucker twenty years ago are still valid and are particularly close to students who enter the labour market after completing their education. Members of the Students Research Group 'Management', participating in many technology trips to European companies, had the opportunity to look at current trends in the area of production management and industrial enterprises. The observations concerned many industries, starting from mining, processing, through food, to automotive. The conclusions drawn from these visits are unambiguous. In order to keep a company in good shape, achieve its objectives and meet the ubiquitous competition, it is necessary to constantly introduce changes and improve processes, regardless of whether it is a large corporation or a small local entrepreneur. There is also a demand for specialists who will be able to support all companies in continuous development. At the same time, a situation is observed in the market, in which students, at the end of their studies, have a difficult beginning of their professional career due to the lack of practical experience at work.

Knowing the demand for specialists and the need for a practical approach to educating engineers, the members of the Scientific Circle have set themselves the goal of creating a project that will teach effectively and practically the knowledge of production engineering and will create an opportunity to acquire key competencies and attitudes on the market while still at university. The idea was to base the whole project on all the principles, stages and consequences provided for in the Lean Manufacturing

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concept - currently the most popular and effective concept of company management.

The AGH LeanLine project is a comprehensive response to the needs and expectations of the final beneficiaries of the project, i.e., students, and thus the broadly understood social and economic environment. It assumes the development of personal competencies, professional qualifications, gathering experience and preparing students to enter the labour market.

Among Polish universities, a novelty is teaching the concept of Lean manufacturing based on a production line made of blocks and following the way to improve its effectiveness with the use of an original didactic algorithm. The above approach is of great importance for an effective, practical output, also based on fun and emotions, and to this innovative didactic process of Lean manufacturing methodology. The whole project also creates an opportunity to acquire soft competencies related to project management, teamwork, negotiation and organization of time and available resources. This is the first such approach known by authors in the world, which is indicated by successive conferences at which they perform with particular parts of the system.

THE BASIS FOR CONTINUOUS IMPROVEMENT

Kaizen philosophy

According to the Kaizen Institute, founded by Masaaki Imai, a pioneer and leader in spreading Kaizen philosophy around the world, Kaizen ('Kai'= change, 'Zen'= good) is the Japanese term for 'better change' (Miller, Wroblewski, & Villafuerte, 2013; Yamada, 1972) and applies to business organisations. Kaizen aims to continuously improve quality for everyone, everywhere and every day. Kaizen activities should either be low-cost or should not generate any costs (Kaizen Institute, n.d.).

This philosophy stems from Japanese management culture and practice, which can be characterized as an endless search for excellence, a process of continuous improvement in the quality of products and services, and the implementation of quick and simple improvements to eliminate losses. It also applies to people, because it is based on employees striving to improve all aspects of the organization's operations, as well as using intelligence and ingenuity, instead of spending a lot of money immediately (Imai, 1997; Tokuda, 2016). Kaizen requires the involvement of all employees of the organization, regardless of their level, in the constant search for ideas to improve the quality and effectiveness of everyday work. In addition, it creates an atmosphere in which companies can solve their problems and focus on eliminating any losses in all systems and processes of the organization.

The aim of Kaizen philosophy is to search for and constantly eliminate waste. In practice, this means taking actions, ideas, and minor improvements, mainly through continuous observation and analysis of processes, Kaizen workshops, employee suggestion systems and quality circles (Imai, 2012).

Kaizen strategy

The Kaizen strategy is based on a common-sense and low-cost approach to management, guided by 10 principles (Liker & Franz, 2011; Liker, 2004):

Problems create opportunities

Problems are an element that is not desirable in everyday life or during the production of the product. However, any situation that causes support to the wall may be useful in the future. This is because each of the individual problems teaches and motivates you to act and tells you how you should or should not behave in a similar situation. This principle is taken from the Japanese culture, according to which the absence of problems is a lack of opportunities for development.

Ask five times 'Why' Principle 5 Why, causes the discovery of problems, which often, at first glance, cannot be seen. The application of several questions makes it necessary to find the causes at the source of their occurrence. Thanks to this solution, you can quickly and effectively neutralize the problem.

Take ideas from everyone

The third principle speaks of teamwork. The team in the case of the company consists of all employees, regardless of whether they are production employees or management staff. Whoever is, an employee has the biggest share in the production of the product and can provide valuable tips and ideas. Ground is listening to someone else's ideas, without which it would not be possible to improve the process.

Think about solutions that can be implemented

Genius is in simplicity. According to this statement, solutions that are often simple and easy to implement are the best solutions to problems. According to this principle, one should not have a head in clouds and not look for original and impossible solutions. Simplicity of action is a priority.

Reject the established state of affairs

There are no ideal solutions; in each case it is necessary to look for even better, more beneficial solutions that bring us closer to the ideal. Courage, at this point, is a desirable feature of character, without which most ideas are not implemented. Bold people are not afraid to make the necessary changes.

Excuse that something cannot be done is superfluous

According to this principle, one should consider how to achieve something and not how not to achieve something, for which something has not been achieved. You cannot make an excuse when you are just looking for a way to solve a problem.

Choose simple solutions without waiting for the perfect ones

According to this principle, small successes should be enjoyed. There should be no unrealistic goals to be achieved in a given situation. It should be remembered that the marathon cannot be run without any preparation.

Use cunning instead of money

According to this principle, it is not possible to realize certain situations without cunningness, even when there is money. In the absence of funding, certain tasks can be carried out on the basis of knowledge that you possess or can study or acquire. The ideal summary of the principle are the words Masaaki Imai, which sound as follows:

'It is not an art to manage efficiently when you have huge financial resources, resources of fantastic experienced experts and great employees. The art is to succeed when you have nothing.'

Correct errors in real time

The ninth rule says that we cannot wait for problems to accumulate, but that all errors must be eliminated before all cases get out of control. Mistakes are a natural thing that cannot be ignored. It is important not to make mistakes after an error.

There is no end to improvement

The content of the tenth rule is not without a coincidence at the end. This is because it says that you cannot rest, but you should always look for improvements. There will always be some area that needs to be improved. The last principle is the beginning of an improvement path that takes place without any downtime.

Using the above principles, it is possible to implement everywhere a Kaizen strategy that teaches problem-solving skills, enables meeting business goals, develops time efficiency in the work of small teams, builds future leaders who will sustain the system, pushes decisions based on consensus down the organization and directs the company's attitude towards continuous improvement.

Continuous improvement

Continuous improvement means concentrating employees on continuous improvement, even small improvements according to the principle: “Don’t focus on big improvements, just try to do what you do today’, a little better than yesterday and a little better tomorrow than today” (Liker & Franz, 2011; Putra & Suef, 2018). The strength of Kaizen strategy does not lie in the scale of improvements, but in the fact that they are continuously practiced at all levels of the company - from management to operators. Referring to management, Kaizen has two main functions to fulfill: maintaining and improving standards. Maintenance is about maintaining current levels of technology, management and operational standards, and maintaining them in a way that is respected by every employee. Improvement, on the other hand, refers to actions aimed at improving the standards currently applied. This is illustrated by the Japanese perception of employee functions in Figure 1.

Gemba Kaizen

“Gemba” is a Japanese word for a real place - currently used in management terminology and for a workplace - or a place where value is added. In production it usually refers to the production hall (Imai, 1997). In this approach, the initiative for change comes not from above, from the management, but from the workplace itself. Gemba manager, who knows his place of work, can manage his continuous improvement. It only makes sense in a specific workplace, in a production hall or in customer contact. Understanding what is happening in the workplace - the Gemba is the basis for all Kaizen improvements (Imai, 2012, 2007).

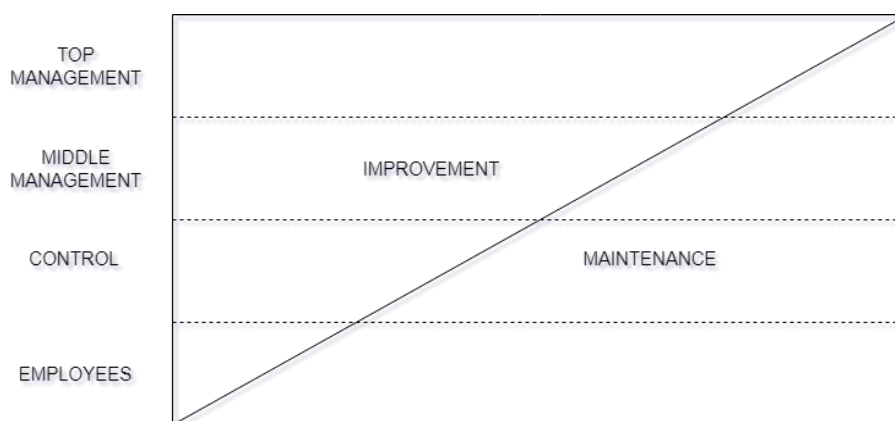


Figure 1. The pattern of the Japanese perception of employee functions

When a problem arises, start with the place of action, i.e., the Gemba - go to the factory floor or the place of adding value and observe. From the perspective of the company, Gemba is an invaluable source of all information about difficulties in the company and the needs of employees.

Check the gembutsu, i.e., the situation and other material objects in the Gemba - look for the cause of the failure. The purpose of this observation is to see what is the source of the problem or what is worth changing in the company. The problem cannot be identified until you see it.

Take temporary remedial action on site. This is another important step in preventing problems. When arriving at the site, appropriate measures should be taken to eliminate the symptoms of the complications studied temporarily.

Look for the direct cause of the problem. Use the technique “five questions why”. This is an effective problem-solving method that involves asking ‘5 times why’ questions. Use it as long as you don’t know the cause of the problem. Identify appropriate standards to prevent the recurrence of the problem. By developing standards well, employees will always know how to act in a given situation.

KAIZEN IN ACTION - ELIMINATION OF LOSSES

Kaizen is a daily standard that takes into account the processes and their efficiency. In order to be able to influence their improvement, it is necessary to be able to see and identify the waste burdened by all kinds of activities throughout the company. There are seven basic types of losses, which are eliminated with the help of Kaizen philosophy (Liker, 2004).

Overproduction

Overproduction is a waste associated with producing larger batches of products earlier and faster than necessary. This is the worst of the strikes, as this situation in turn, results in the storage of products, product formation, shortages, waiting for other products and the associated unnecessary transport and movements. As a result, these actions also generate unnecessary costs, which directly affect the financial situation of the company.

Waiting

Waiting includes time spent waiting for reports, information, signatures and approvals, co-workers, operator or machine. This loss results in an extended production cycle, delays in delivery to customers and failure to meet deadlines.

Transport

Transport concerns unnecessary movement of machinery and unnecessary movement of raw materials and finished products. This type of waste increases the risk of damage, pollution and quality defects, as well as worsens communication.

Excessive processing

Excessive processing can be associated with unnecessary operations, frequent and unnecessary controls, as well as additional work on a product that does not create added value. It can be caused by a bad organization of the process and misunderstanding of the client's expectations.

Unnecessary movements

Unnecessary movement refers to unnecessary movements made by employees during their work at the workplace. These include searching, bending unnecessarily, and reaching for objects that are far away from the position. It may result from the poor organization of the workplace and its mismatch with the ergonomics of human movements.

Stocks

Inventories include finished products, work in progress, parts or semi-finished products, awaiting the next stage in the production or distribution process. They generate unnecessary storage costs. Sometimes some of them have to be discarded after some time due to the limited validity period.

Shortcomings

Shortcomings are related to insufficient quality, which may be manifested in: delays, repeated checks and corrections. They can be caused e.g., by a mistake on the part of employees or by the delivery of defective components for production.

TYPES OF KAIZEN

Kaizen flow is based on the improvement of the entire value stream. This includes: improving the flow of materials and information on the basis of VSM, reorganisation of the entire production area, and focusing on the whole (Lean Trix, n.d.). Senior management is responsible for this type of Kaizen.

Kaizen process is based on the improvement of individual processes, which include: small ideas of employees, small implementation effort, and focus on a specific activity. Responsibility for this type of Kaizen rests with the employees who carry out the process.

Implementation time of Kaizen

During the implementation of Kaizen, the risks associated with the duration of the measures should be borne in mind. This relationship is shown in the diagram in Figure 2.

Kaizen maturity

Kaizen is the most effective strategy for increasing the competitiveness of the company, creating a culture of continuous improvement through the implementation of a habit of constant change in all employees in the company. The maturity of Kaizen is presented in Figure 3.

IMPLEMENTATION OF KAIZEN

Kaizen implementation process

The Kaizen implementation process consists of several important elements, the implementation of which is necessary for the correct implementation of Kaizen. Implementation of Kaizen includes:

- constant observation and searching for problems,
- problem analysis and problem definition,
- the search for causes,
- preparation of the solution,
- the trial in practice and search for irregularities,
- implementation and control of results,
- standardisation

There are several ways to implement Kaizen in your company. One of them is the 'Kaizen workshops', which come from American companies. These are optimization workshops, which usually last 5 days. It is also possible to use a method that allows a high degree of involvement of all employees. It is the so-called 'suggestion system', which consists in improving in small steps by employees submitting ideas for new, often minor improvements, and then verifying and implementing them. This system is characterized by a very low investment threshold. There is also the concept of 'quality wheels'. It is also one of the ways to implement Kaizen, which consists of creating a team consisting of a small number of the best employees, whose aim is to improve the quality of products and production processes.

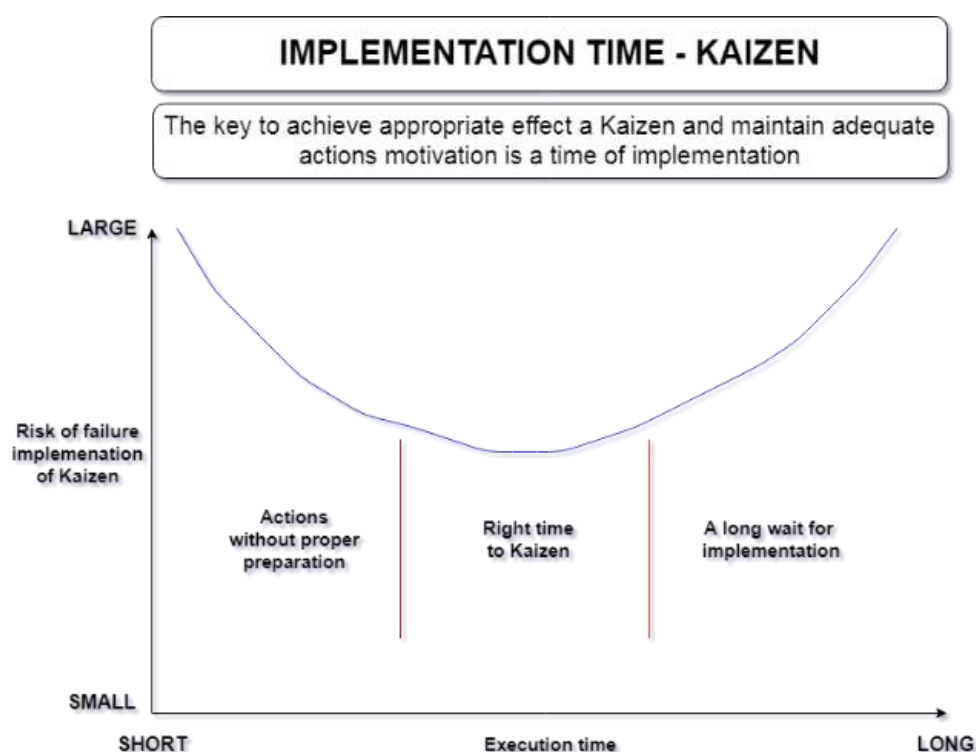


Figure 2. Implementation time - Kaizen. Source: Imai (2007)

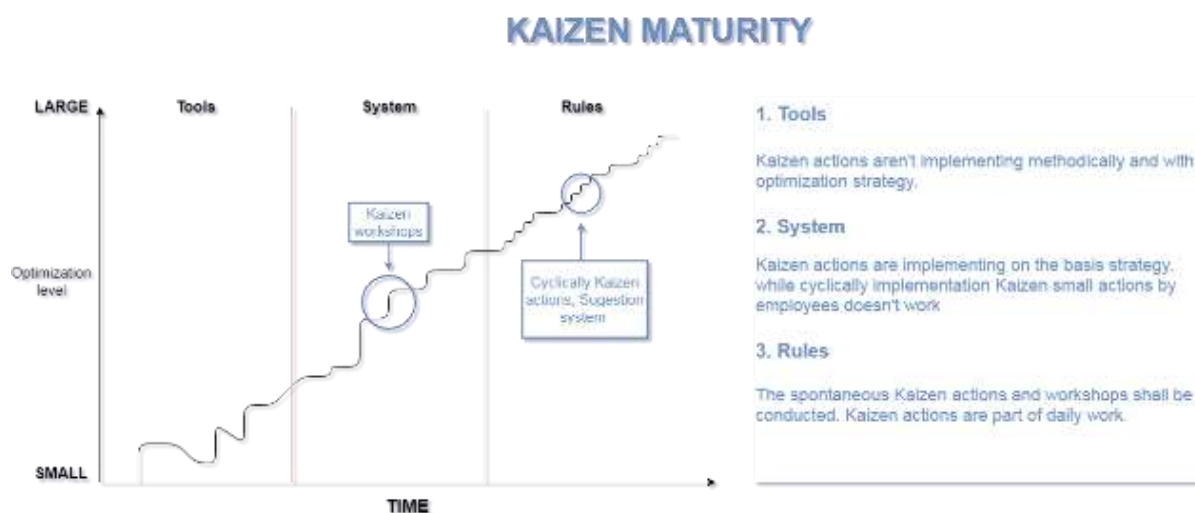


Figure 3. Maturity of Kaizen. Source: Imai (2007)

PDCA cycle and standardisation

The implementation of Kaizen is closely related to another known Japanese method, which is the PDCA cycle, also known as the 'Deming cycle'. This method, developed by American statistics in the 1950s, defines the basic Kaizen principle of continuous improvement.

This cycle presents four actions on which the whole philosophy of Kaizen is based, so one can say that these are the four pillars of Kaizen. These activities, as listed by Liker and Franz (2011), are:

- Plan - create an action plan to make the process more efficient,
- Do (execute) - implement the plan,
- Check - identify waste and problems at each stage of the process,
- Act (amendment) - take corrective action to correct the irregularities detected in the previous step.

In the first stage of the PDCA cycle, i.e., planning, it is first of all necessary to identify the process that needs to be improved. Improvement may be related to bottlenecks or delays where effectiveness does not meet the customer's expectations, or where actions taken in the areas concerned have an impact on the market and the entity's finances. Once an area for improvement has been identified, it is necessary to consider ways of eliminating visible waste and plan actions that will help to eliminate it. At this stage, a team of people is also selected, as well as measures that will help to achieve the desired goal quickly.

In the 'do' stage, the implementation of the plan begins. An important issue at this stage is that the team understands the problem and investigates it. Often at this stage an up-to-date map of the process is created, which also helps in the subsequent analysis, which is carried out in the third step. This stage shall be carried out in the shortest possible time and each member shall be assigned a role.

After the implementation of the plan, it is necessary to proceed to the observation of the activities carried out. At the 'check' stage, a number of measurements are made and a process map is created after the execution of Kaizen. This is where the map created in the second stage helps, because it is necessary to compare the two maps of the process being improved and to analyse whether the steps taken were right, and whether the new way of implementing the measures brings the intended results. A comparison of process maps before and after implementation of Kaizen also helps to detect problems that were not visible before.

The last but not least important step is the 'improve' stage. If a Kaizen has been successfully implemented, the new way of implementing the measures is accepted as an official procedure, but if another problem has arisen that does not allow the whole Deming cycle to reach a satisfactory level, the whole Deming cycle should be restarted.

The PDCA cycle focuses on improving the process through improvements, but as new regulations are introduced, each process becomes unstable. In such situations it is necessary to focus not only on improving the way in which individual actions are implemented, but also on introducing new standards that help to implement these actions in an easier and quicker way. This is what the Standardize, Do,

Check, Act (SDCA) cycle is for (Liker & Franz, 2011; Kaizen.com.pl, n.d.).

The SDCA, like the PDCA, consists of four steps. However, a significant equator appears already in the first step, where 'standardization' appears in the place of 'planning'. The SDCA cycle is therefore as follows (Liker & Franz, 2011; Kaizen.com.pl, n.d.):

- Standard (Standardize),
- Do (Execute),
- Check,
- Act (amend)

In the case of the SDCA cycle, the first step is to create standards together with the employees concerned - the 'Standard' stage. In the next steps, the standards should be implemented (stage 'To'), the standards should be compared with the current situation and the correctness of the standards should be verified (stage Check) and then, if necessary, on the basis of the results of stage three, steps should be taken to modify the standards.

Both cycles are therefore the basis for maintaining change, but the difference is that the PDCA cycle streamlines the process and the SDCA standardizes and helps to stabilize the current process.

Kaizen Workshops

Kaizen Workshops is the next step towards continuous improvement of the process and, above all, the awareness of employees performing tasks at the production stand. The procedure of organizing workshops begins with the initiation and preparation, in which initiating meetings are organized and work related to the preparation for their implementation. The next step is the implementation of the workshops, during which the following stages will be carried out (Liker & Franz, 2011):

- presenting the problem to be solved - the aim of the workshop,
- analysis of the current situation,
- change planning,
- implementation of the plan,
- a summary of the results obtained

The workshop is followed by the continuation of the activities, which is a long-term plan for managing the activities set out during the workshop.

IMPLEMENTATION OF KAIZEN WORKSHOPS

Initiation

The first step of the initiation is to prepare the necessary analyses to identify the key areas of Kaizen activities. Examples of tools that support the selection of the most important processes are SIPOC diagram, impact matrix and maturity matrix as well as a map of the current and future state created during the value stream mapping. It is also very important to analyze the bottlenecks, which will identify processes that require urgent intervention to ensure the best possible flow of added value.

The next step in the initiation of Kaizen activities is to choose the type of workshop depending on the process it will concern. Continuous improvement is supported by a number of methods and tools derived from the Lean Management methodology. It is a concept of company management, which has been developed on the basis of the principles of Toyota's production system, emphasizing the creation of added value for the customer and the elimination of process losses. Therefore, it is necessary to select a workshop in a specific area, which is to bring a specific result, e.g., SMED, Lean Logistics, 5S & Visual Management, Process Management, TPM, Layout or Standardization (Liker & Hoseus, 2008; Liker & Meier, 2005; Ćwiklicki & Obora, 2014).

Preparation

After selecting the process and the type of workshop, the preparation stage takes place, in which the identified problem should be described in detail, the team and the scope of activities of individual persons as well as their training, the logistics of the workshop should be designed, which includes all kinds of schedules, as well as a list of necessary resources and financial analysis of the project.

The course of the workshops

The aim of this phase is to identify, validate, and implement real process improvements, based on preparation and analysis. During the workshop it is worth combining the technical aspects of activities as well as a softer approach, taking into account the opinion of each team member and creating a positive atmosphere for minds open to change. Workshop participants should be open to changes.

The most important element of this step is the observation of processes according to the sequence of operations. In order to do this, one has to 'go to the Gemba' and observe the process in order to get to know the actual state of affairs and identify the problems that will have to be solved. On the basis of the obtained data and observations, a list of improvements in the form of a Kaizen database is drawn up, which will constitute the main document for managing activities within the scope of process optimization.

In order to carry out a reliable waste analysis, it is also worth to use a detailed process observation sheet, which will allow you to identify losses on an ongoing basis. It will be an extremely important document from the perspective of planning future activities related to the elimination of unnecessary activities, e.g. combining processes in order to eliminate inventory, implement a way of monitoring tool wear, and replace the layout of machines or implement a production order management system.

Follow-up

Following the path of continuous improvement proposed by Masaaki Imai, it must be stated that the implementation of Kaizen workshops and the identification of elements to be improved is only the first step to reap the benefits of this philosophy. In the next stage it is necessary to ensure a standardized continuation of activities within the framework of Kaizen, i.e., implementation of long-term action plans and a system of communicating the results to the company's employees. For this purpose, among other things, a benefit report is used. It is a tool to identify predicted and actual, achieved, measurable results, such as, for example, the following:

- percentage of reduction of the total processing cycle time,
- percentage of reduction of bad quality cost

KAIZEN TOOLS AND METHODS

There are two types of methods used in Kaizen activities. The first one is methods allowing for effective development of solution proposals on the basis of a database, and the second one is methods facilitating decision-making and selection of the best solutions. Among the tools and methods available, it stands out among others (Knosala, 2017):

- Pareto-Lorenz diagram,
- Report A3,
- Report 8D,
- 5Why analysis,
- Analysis 5W2H,
- Ishikawa Diagram,
- Poka Yoke,
- Standardization,
- 5S,
- Spaghetti diagram,
- Balancing operations,
- Method of voting,
- Selection of the solution according to the criterion,
- Comparison of 'each with each',
- Method of cost-benefit analysis

AGH LEANLINE - PRACTICE MAKES THE MASTER

In order to benefit from the goodness of Kaizen philosophy, identify and eliminate waste during workshops and effectively manage process optimization, it is worth trying your hand at laboratory condi-

tions. The best way to educate is through practical workshops - a combination of theory and actions that can be applied and tested in practice immediately. AGH LeanLine is a project of the Student Research Group 'Management', operating at the Faculty of Mining and Geoengineering of the AGH University of Science and Technology in Krakow. It consists of designing and manufacturing a production line with the use of LEGO Mindstorms EV3 brake pads and modern technologies used in real companies. The production line can be equipped with various elements to best reflect the production environment, such as the Vorne 800XL, which allows automatic downloading, analysis and visualization of data from machines and workstations, as well as various sensors to inform users about specific events during production. The resulting constructions will be used to build simulations of the production process, during which the participants will learn and put into practice the knowledge about production optimization. These elements of the production line will allow the practical application of methods and tools resulting from the concepts of Lean Management and Kaizen and control the effectiveness of their use depending on various variables. The use of automatic robots made of LEGO blocks gives the possibility to simulate the real conditions in production companies, so that young engineers can gain experience already at the stage of education.

Uniqueness of the project

There are many simulation games available on the market, based on further attempts to improve the production process. However, they are usually limited to the following standard steps, which include the organization of the warehouse, the arrangement of production sites according to the course of the production process, specialization of employees from operations performed at individual sites, the development of simple instructions and visual management elements, as well as the elimination of bottlenecks that limit the efficiency of the production process.

Undoubtedly, these are very practical issues in the design and optimization of production processes, but in reality, there are many more factors and variables that need to be taken into account when managing production. First of all, we should remember about machines and equipment, which are an indispensable element of production companies, especially in the era of Industry 4.0. Employees responsible for the organization of work in factories, because they must focus not only on group work, training of employees and the visual aspect of their workplace, but also on the limitations resulting, for example, from the working time of machines.

The uniqueness of this project is the ability to collect very accurate data, which in traditional simulations is practically impossible, having only a stopwatch at your disposal. Robots created from LEGO blocks will be programmed in such a way that after calling by an employee of an appropriate program, the start and end times of the operation will be read with an accuracy of seconds. This way of data collection will give the workshop participants true and reliable information on the basis of which they will be able to formulate precise conclusions. Thanks to the ability to collect data to previously prepared formats and reports in Microsoft Excel and Vorne 800XL, after the course of each simulation, employees will receive feedback on the results they have achieved. On this basis, students will be able to assess on an ongoing basis whether the ideas introduced bring the desired results and introduce further improvements.

AGH LeanLine is not only about the production process, but also about many production support processes, such as logistics. The use of properly designed driving structures will enable optimization of logistics of supply of raw materials and tools for particular stations, as well as transport of finished products. In the created production line, the role of logistics will be taken over by a vehicle built of blocks moving along the route marked out by the participants, in such a way as to provide the right amount of materials to the right employees at the right time, and thus in accordance with the Just-in-Time concept. In the course of his work, data will also be collected, i.e. transport time and the length of the route covered, which will then be analyzed (e.g., Spaghetti diagram), which will further broaden the range of methods and tools used during the production process.

Beneficiaries

The complete production line, which allows for additional improvements, based on observations, analyses and conclusions drawn by the participants, can be used during the second degree of studies 'Management and Production Engineering' and then 'Engineering and Industrial Process Management'. The 'Lean Manufacturing' specialization carried out within the above-mentioned fields of study fully dedicates the content of the methodology of the same name, therefore, the presentation of its practical application on the created line would be an ideal culmination of students' education, at the same time increasing their professional competencies.

PRODUCTION PROCESS SIMULATIONS AS KAIZEN WORKSHOPS

Each simulation of the production process is a Kaizen Workshop, during which losses occurring in the basic model are defined and then eliminated from the value stream using known methods of process organization. Such training is an active passage through the PDCA cycle, undertaking and testing all activities included in each stage. Thanks to such projects, students experience the practical application of theory and are ready to take such actions on a living organism a production company.

Initiation in practice

According to the methodology of Kaizen workshops, following the standards of such actions taken from production companies, the first step to the implementation of the workshops is the initiation stage. Students will go through it carrying out various analyses in order to identify key areas for further action.

The next element of the initiation stage is the choice of the type of workshop depending on the process it will concern. It is an ideal place to test many tools and methods embedded in the Lean Management methodology.

Preparation for workshops in practice

The preparation stage, carried out immediately after the selection of the process and type of workshop, is the best moment to try to describe in detail the problem identified through the analysis. This is an opportunity for students to rethink their plans and resources to efficiently carry out the main activity-the Kaizen workshop.

The course of the workshops

At this stage, further of production processes will be started, during which students can observe selected processes and implement solutions aimed at their improvement.

The first document at the students' disposal will be a process observation sheet (Figure 4), in which such operations as preparatory, basic, additional, completion and disruptive ones will be specified, along with their duration in subsequent production cycles. In addition, the worksheet is equipped with other variables, which may contribute to better analysis and improvement of the selected process.

Another very important document from the perspective of Kaizen workshops is the wastage analysis sheet (in Figure 5), which emphasizes the basis of this philosophy, prompting the observer to identify different types of wastage. Especially for young engineers, it is very important to learn from the very beginning to see the potential risks and opportunities to eliminate them.

On the basis of the obtained data and observations, a list of elements for optimization is prepared in the form of a Kaizen database (Figure 6), which will constitute the main document for managing activities within the scope of process optimization. It is a database of information that should be systematically supplemented, their statuses supplemented and those responsible for the implementation of the tasks assigned to them.

SIGHTING SHEET

(Who: O – operator, F- Foreman, WA – Warehouse attendant)

WORKPLACE:										Number of workplace:		
Date:					Observer:							
Inventory (name) before (numer of pieces.):			Time measurements (s)					Inventory (name) after (numer of pieces.):				
Nr	Operations	1	2	3	4	5	VA	Who	Series (pcs.)	Quality (%)	Transport	Problems
1. Preparatory operations)												
2. Basic operations (in the cycle)												
3. Additional operations (on lots)												
4. Completion operations												
5. Disturbance activities		Measurements					Frequency per shift					

Figure 4. Process observation sheet

Drafted						Date								
Process						Types of waste								
Lap	Route	Time [s]	VA	NVA	W	To big an order	Unnecessary movements	Waiting	Transport	Additional processes	Stockpiles spoilage	Ergonomics	Remarks	Solutions
1														
2														
3														
Sum														
[%]														

Figure 5. Waste-disposal analysis sheet

Nr	Effect-information	Effect [min/month] reduction of problems	Profit [zł]	Cost [zł]	Percentage of average set-up time saved	Reduction [min] in average set-up time	DATA	Value	Unit
1					0,0%	-	Variable 1	1	okolo
2					0,0%	-	Variable 2	1	
3					0,0%	-	Variable 3	1	min
4					0,0%	-	Variable 4	1	min
5					0,0%	-	Variable 5	1	mina
6					0,0%	-	Variable 6	1	min
7					0,0%	-	Variable 7	1	min

Nr	Date	Workshops	Process - lvl 1	Process - lvl 2	Process - lvl 3	Problem	Kaizen	Responsible	Withheld	Plan	Do	Check	Act	Date - realization	Effect	Cost
1																
2																
3																
4																
5																
6																
7																

Figure 6. Kaizen database

Follow-up

During practical workshops in the last step, students will create a report on the benefits of the changes introduced and learn how to plan long-term actions, which should be sustained so that Kaizen is not just an occasional improvement action, but is rooted in the company as a culture of continuous improvement.

PLANNING EXAMINATION OF THE EFFECTIVENESS OF THE PROJECT

Diagnosis of a group of students

Before starting the Kaizen Workshop and working at AGH LeanLine, students will be diagnosed with their current competencies by means of an interdisciplinary survey. It will include questions from theoretical issues within the Lean Management methodology and production management, as well as many 'soft' aspects related to experience, communication skills, negotiation, exposure and interpretation of data and team management.

Evaluation

After the workshop, another study will be carried out, which will be aimed at assessing the usefulness of the implemented measures and the level of competence and skills growth of the training participants. The evaluation of effectiveness will again include an interdisciplinary set of questions, which will make it possible to measure learning outcomes through practice with AGH LeanLine.

Monitoring of professional development

The programme will be equipped with an examination of professional competencies and career path of the students participating in the workshop, in order to be able to examine the effectiveness of the project already at the stage of professional work. The survey will include questions about job interviews in companies and the way of development in the company. The survey will take into account the usefulness of the acquired competencies during the workshop during recruitment interviews and in companies. It is important to assess whether students, through apprenticeship education, have been able to make use of their work experience, whether they perceive its long-term effects and whether the competencies they have acquired have contributed to a better position in the market.

CONCLUSION AND RECOMMENDATIONS

In Lean Manufacturing methodology the most important issue is continuous improvement. However, in order to be able to develop, you must first notice problems and errors, and then, after identifying the problem, it is important to fully understand it. Only then can you take steps that will lead to the elimination or alleviation of the problem.

In existing companies, employees are the closest to the problems arising in production processes. Therefore, in line with the heart of continuous development, which is Kaizen, these people should be allowed to make changes. Thanks to this, we increase their involvement by involving them in the process.

It happens that it is difficult to imagine the effects of changes, so before serious steps are taken, it is in fact worthwhile to simulate the chosen solutions and observe their effects, in order to be able to assess whether they are correct without exposing the individual to losses.

Among other things, AGH LeanLine was created for such situations. Not only because this production line, built with Lego blocks using Vorne 800 XL software, has become an innovative solution that helps to understand Lean manufacturing methodology through the possibility of practical application of tools in simulations whose level of difficulty is adjusted to the age, level of advancement and individual needs. Based on the heart of the presented methodology, he teaches Lean Manufacturing as a whole in a comprehensive way and makes it much easier to understand the individual tools of this methodology.

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