Evaluation of a New Concept of a Knowledge based Environment

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Abstract

The objective of this paper is to show the evaluation of a new approach for the management of knowledge in lean product development. For this, a knowledge based environment was developed and implemented within a development department at a large automobile manufacturer. This knowledge based environment captures the knowledge of the designers. When the designer starts a new project, the environment provides this knowledge to the designer to support him in decision making and problem solving. The evaluation gives an insight of the state of product development before and after the implementation of the new approach of the knowledge based environment. The assessment tool and the approach are explained and some results are presented.

Keywords: knowledge management, knowledge capture, knowledge based environment, lean development, lean self-assessment, LeanPPD, ontology based.

1 Introduction

Today, in modern manufacturing industry, especially in the automotive sector, a strong competition between the manufacturers and a shorter product life cycle of the products result demands for more efficiency in the product development process. However the product development costs are increasing because of the rising number of models, the fast progress of technology and the incrementing complexity of the product [1].

To increase the efficiency in product development, companies try to implement the principles of lean into product development and product emerge process. But in this process, the identification and reduction of wastes and the boosting of value are not that easy to realize than in production processes. This is, because more new, innovative and unique projects are done in development with cycles of often about several years. This is contrary to the production, where always similar products in short cycles are produced in exactly defined process chains. So the optimization of processes in development has completely different challenges than in production [2].

This new paradigm – lean principles applied to the product development phase – is called Lean Product Development.

Within the finished EU-funded project LeanPPD (Lean Product and Process Development), new methodologies, methods, design techniques and tools were developed by a consortium of universities, research and technology development companies. These results were implemented at several industrial partners locations. Many tools and concepts of Lean Product Development were transferred, implemented, tested and evaluated within a development department in the component division of the Volkswagen Group, which is one of the world's leading automobile manufacturer and Europe's biggest carmaker [3].

This paper will focus on two of these tools. Whilst the Knowledge Based Environment (KBE) was implemented in the development department, the Lean Self-Assessment Tool was used to make an evaluation before and after the implementation of the KBE.

2 Knowledge based environment

The knowledge based environment (KBE) was developed to support the product designers in knowledge management and decision support during the product development process. This chapter will give a short overview about this tool.

2.1 Requirements

To meet the demands of the product designers at Volkswagen, in the beginning of the project many interviews and evaluations in the development department were carried out. As a result of these the following functional requirements for the KBE were defined [4]:

(a) All relevant knowledge and documents from past projects should be collected and stored so that the designers can obtain them quickly.
(b) A search function should be enabled to locate and retrieve the most important project knowledge.
(c) A function should be provided to visualize the knowledge that the designer needs to make new decisions.
(d) Knowledge should be captured dynamically in an easy way throughout the whole product development phase.
(e) The key lessons learned from different stages of the products development process and from the previous products should be provided to the engineer.

2.2 Implementation

The KBE is installed on a server in the intranet environment of the automobile manufacturer and supports a web interface so that it can easily be accessed and used online via the web browser. This way, every person, who is relevant for the component or part, could access the knowledge based environment. These people are not only the designers and developers, but also experts from the planning, testing, quality and manufacturing department. So the KBE can capture the knowledge of these experts, too. This is especially useful with lessons learned expertise from previous projects, which can be used again in new starting projects to integrate the modifications at the beginning of the designing and construction of the part.

A user management system was established to control the activities of the users because different types of users can perform different actions in the KBE. Starting with key users who can add new projects and parts, over designers who can add changes to parts through to users who only have read only rights to get informed about the change.

2.3 Approach

The approach of this tool is to combine knowledge management with an ontology based structure of knowledge, which is linked to the parts and processes. Through this mechanism the designer is supported in decision making and gets the right knowledge at the right time for the right component or part.

To achieve this aim, the designer documents all changes that he does in the KBE while constructing the part in a CAD modeling software. These changes are collected to the specific part which is designed, and appear in a so called part history. In this history, the part version, the change that was made, the reason for the change and all ensuing consequences of the change, are captured. These changes contain a lot of expert knowledge and information [5].

In the context of this work, knowledge is defined as skills and competence of an individual to resolve problems [6]. The advantage of the knowledge based environment is that the storage of knowledge takes place without any additional effort for the designer. The tool is integrated in the regular change management workflow of that department and does not take any additional effort from the designer. Before the KBE was implemented, the designers used a more time-consuming method to document their changes.

The core of the KBE is an ontology related approach, which makes it possible that the designer is given the knowledge from similar previous parts and projects, while he is designing a new part. This is the knowledge from changes that were made on a previously designed part. Because most of the parts are similar and the problems that have to be solved are analogical, it makes sense to propose the designer the parts from previous projects or parts with mostly the same attributes, e.g. the same surface, material, manufacturing process, supplier etc.

For this, an indexing service is running in the background, which monitors the changes in the parts in order to extract the actual context to further enhance it with the corresponding knowledge. The indexing service extracts the most relevant words in the change logs and other sources and provides it to the user in different ways to support him in decision making.

2.4 Features

Beside the above mentioned ontology approach, the designer gets a set of additional features, which facilitate him in knowledge management and decision support. These features are in detail [5]:

(a) A special search mechanism, which allows the designer to easy get access to knowledge from previous projects. This includes search by product and part, by project phase and date, free text search etc.
(b) A collection of design rules, which supports the user in applying lean manufacturing rules, related to the specific part.
(c) A tagcloud shows the designer the most invoked changes and design rules.
(d) Over a notification every user can see the status of the recent change, whether it is authorized, already implemented in the tool, if it is pending or if it is dismissed.
(e) An add-on was built that the designer can get a listing of all changes of the part as a PowerPoint file for presenting purposes.
(f) Notification of all necessary participants via email, if a new change is documented and needs input from other users.

2.5 Benefit

The advantages of the knowledge based environment are as following:

- Storage of knowledge takes place without any additional effort for the designer. It can be easily integrated in the daily workflow process of the designer and it helps him, because it is done over an intuitive and easy to handle interface.
- Avoidance of additional work, especially similar or the same work that was done already before, unnecessary process steps and inefficient information transfer.
- Reduction of development time, because the optimization loops of parts can be reduced

- Increase of product quality because many options can be considered and lessons learned can be integrated in the new solution
- Cost reduction because of the above mentioned points
- The designers are sensitized for the need of knowledge management in product development and the exchange and transfer of expert knowledge between the designers and from one to another are increasing.

3 Lean Self Assessment Tool

3.1 Origin

Because the lean thinking approach is a continuous improvement process in the company, an instrument is needed to track this process inside the company. The Lean Self-Assessment tool provides a ready-made platform to evaluate and report the maturity level of lean thinking in new product development of an industrial company. It can also track the progress of the implementation of the other LeanPPD tools during the project phase until the end of the project. To realize this, the tool is based on the Balanced Score Card model (BSC) of R. Kaplan and D. Norton, which is shown in **Figure 1**:

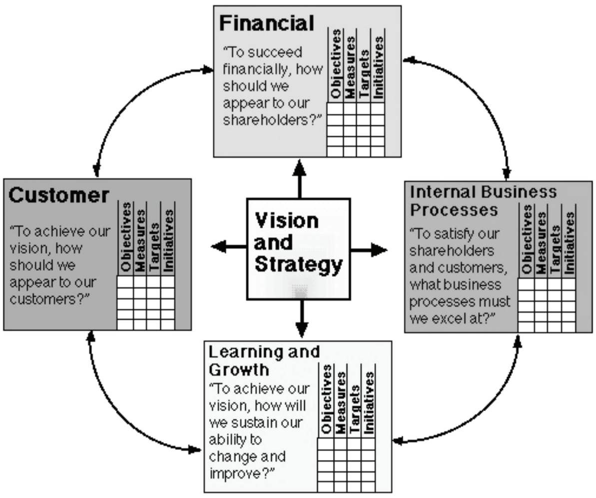

Fig. 1 The Balanced Scorecard (BSC) model

With this semi-standard structured report it is possible to track activities in the company and control and monitor the consequences that result of the activities [7].

3.2 General

For the LeanPPD project, this model was adapted to meet the requirements of the industrial partners and consider the philosophy of lean thinking.

The self-assessment can be configured to measure the level of leanness of a company in different ways. For example the whole enterprise can be chosen as an organizational unit or only a business unit of it or a single department. Also it can be chosen if the type of assessment is a personal (one person is interviewed) or group (a few persons are asked) assessment. For the tracking of the progress it is possible to determine different assessment periods, e.g. 3 months, 6 months or a year. All types of assessment can be used in an anonymous benchmarking mode, so that companies can compare their results to the performances of other similar companies without publishing too much internal information.

The functionality of the tool consists of two main parts: a qualitative assessment and a quantitative assessment.

The quantitative assessment is called "Lean T2 measurement framework" and uses quantitative key performance indicators (KPIs) to measure five different levels of readiness. For this, a library of performance KPIs has been created for industrial companies. With these KPIs, it is possible to give these companies a method to measure the progress with very precise indicators. On the other side, the company has to provide all quantitative figures and KPIs to the tool to get a usable result [8].

The qualitative assessment has the name "S.M.A.R.T. lean-T2 readiness tool" and uses a five step change process of lean best practices to identify the "As-Is" state and define the aim "To-Be" of the lean thinking paradigm in product development.

For the purpose of lean product and process development, the tool was modified to meet the requirements of the development activities in each of the companies.

In this paper, the focus is on the qualitative assessment tool, because this method is more effective to measure the impact of the implemented tools in the business case of the automobile manufacturer.

3.3 The five readiness levels

As mentioned above, the five main steps show the company or department the current level of lean readiness in product development:

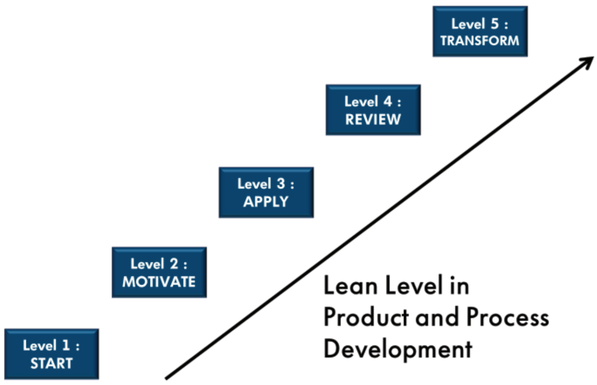

Fig. 2 The five levels of lean readiness

The five stages, as illustrated in **Figure 2**, consider the following:

- Level 1 (Start): The company does not implement lean practices in its product development.
- Level 2 (Motivate): The company is aware of Lean philosophy and lean practices and is starting to implement them in their processes.

- Level 3 (Apply): The company is using lean practices and lean design in its product and process development and has achieved a basic level of implementation.
- Level 4 (Review and Improve): The company is using lean product and process development practices and measures the results continuously to implement improvement actions.
- Level 5 (Transform): The company uses lean best practices and shares them internally and externally

3.4 The four perspectives

Based on the Balanced Scorecard model, the fields, which cover all essential aspects of lean product and process development, are the four perspectives, as shown in **Figure 3**:

Fig. 3 The four perspectives of the lean self-assessment

These are as follows [8]:

- Perspective 1 (Cost, Time and Quality Measurement and Improvement): This perspective will help companies to assess their practices to enable cost and time reduction and quality improvement thanks to the application of Lean Thinking in product development.
- Perspective 2 (New Product Development Process): To be competitive in the market, companies should have a well-defined product development process which considers sustainability aspects throughout the product life cycle and that maximizes the value delivered to customers by eliminating waste.
- Perspective 3 (Tools): In an effective product development process, tools and methodologies are necessary to facilitate people to execute their work in the most productive way.
- Perspective 4 (Skilled People): People are most important in a company. It cannot compete in product development without a capable, energized and aligned team that executes lean thinking in their daily activities.

Within each of these perspectives, there are 14 questions. Each question has five statements, so-called lean practices, which reflect the five (S.M.A.R.T.) levels of lean readiness. The user has to select that one, which fits best to the recent state “As-Is”. In a second column he can choose, which the company’s desired maturity state is “To-Be”. In a third column the relevance indicates the importance of this statement for the department or business. If the statement cannot be answered, or the user does not want it to be evaluated, he can exclude it by choosing “N/A” as an answer.

3.5 Evaluation

After filling out the online version of the self-assessment tool with all four perspectives and all the 56 questions, the user has the option to get all the results shown in an overview. This overview illustrates the four perspectives in radar charts and a tabular layout of the questions and given answers. It creates a current lean level for each perspective by taking the average of all “As-Is” answers. An overall lean level (Fig.2) out of the averages of all lean levels of the four perspectives gives the company or department an impression of the lean readiness level of it.

4 Results of the evaluation

In the scope of the shortness of this paper, only one perspective will be discussed in detail. The author will focus on the third perspective, tools, because in this perspective, the improvements and the impact that are caused by the implementation of the KBE are excellent to illustrate.

The assessment was done during the LeanPPD project in a development department of an automotive manufacturer. Before the implementation of the KBE a so-called initial self-assessment was carried out to investigate the existing level of lean product development in that department.

After the application of the new approach and the KBE, the assessment was carried out again to expose the benefit of the KBE including knowledge management and decision support.

For this, the 14 questions or so-called statements in the perspective tools cover different objectives, e.g.:

- The reliability on a clear leadership of lean in new product development.
- The clear definition and documentation of customer values.
- The application of tools to improve the quality in product design.
- The use of a tool for knowledge and information sharing, storing and reusing.
- The collaboration of the company with external experts (e.g. universities, laboratories,, etc.) and other companies (e.g. competitors, companies in the same sector).
- The implementation of set based design techniques in product development, where several options are considered in parallel.
- The tracking of collaborative decision making in set based design across different departments and teams within the company.

Subsequently a few highlights of the results will be discussed.

4.1 Initial assessment

Figure 4 illustrates the radar chart of the third perspective, where the red line is the “As-Is” state of the department and the blue line shows the "To-Be" state.

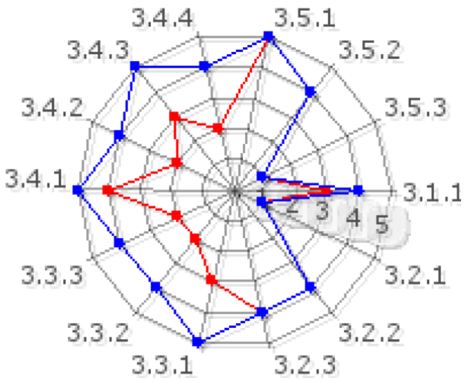

Fig. 4 Radar chart of initial assessment before the implementation of the KBE

It shows that in six statements, there are no needs for improvements. This is mainly due to two reasons: first because for the automobile manufacturer it is very important to keep the knowledge and competence of product design and development, in-house to save intellectual property of his innovations and products. Because of this, not many external partners are integrated in the product development phase. Second, the organizational structure in the company and department predetermines a lot of processes and practices, which cannot be altered in the short-term.

The other eight statements show at least a level of 2 (Motivate) with a potential of one or two levels to reach the desired level. This includes the statements of an application to improve quality in product design and a tool to increase the knowledge management in product development and decision making in set based design.

4.2 Final assessment

After the implementation of the knowledge based environment and one year after the initial self-assessment, a second assessment was done in the same department. **Figure 5** shows the results:

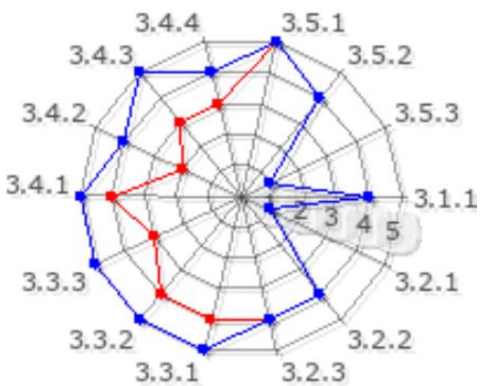

Fig. 5 Radar chart of final assessment after the implementation of the KBE

In the figure above, the "As-Is" state of a few statements raised. The enhancements are in detail:

- A complete self-assessment cycle has been carried out to identify improvement opportunities in the product development process (point 3.1.1).
- A tool and a methodology to capture, store re-use relevant knowledge in product development was established and knowledge can be found easier without any big effort (point 3.3.1).
- A tools and a process was found to identify the knowledge needed in the product development process (point 3.3.2).
- Experts can be identified easily through a skills directory implemented in the tool (point 3.3.3).
- The provision and use of clear guidelines or tools to increase parts standardization through the designer was increased (point 3.4.4).

Furthermore, the "To-Be" state of some statements during the second assessment in this department increased (points 3.3.2. and 3.3.3). This has to do with the fact that the product designers and leaders got aware and sensitized in the use of knowledge management in product development. By working with the KBE, the designers got to know the approach and the features of that tool and with this potential, they increased their expectations of knowledge management in product design.

Summarized for the whole perspective, the current level of the perspective tools is described as the intersection of all 14"As-Is" values of the perspective. Before the implementation of the KBE in the development process of that department, the overall level was 2.86. In the final assessment the value rises to 3.29.

5 Conclusion

This paper gives an overview over a new approach of a knowledge based environment which is used for knowledge management and decision making in product design and the validated evaluation of it. Both the KBE and the self-assessment tool were described and the method of evaluation was explained.

The evaluation shows that the implementation of the KBE helps the development department as a whole and the product designer in particular in knowledge management and decision support in the product development phase.

As a result of the self-assessment tool, the department has developed and increased its level of using tools for lean development. Starting from the state of being aware of lean philosophy and starting the implementation of lean tools upon the next level, it improved to a level, where lean practices are used in process and product development and where an advanced level of implementation is reached.

The next steps will be to establish the use of the available tools and sensitize all designers for knowledge management and transfer in product design. The potential of the KBE can be increased by adding other features to relieve the product designer in his work and in making decisions to increase the product quality and minimize optimization loops to reduce costs.

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