INTERNATIONAL DESIGN CONFERENCE - DESIGN 2016
Dubrovnik - Croatia, May 16 - 19, 2016.

LEAN INNOVATION METHODS: APPLICATION & EVALUATION DURING A STUDENT PROJECT

S. Rötzer, J. Wilberg and U. Lindemann

Keywords: lean innovation, lean product development, case study

1. Introduction

The globalization, the shift towards buyer markets, and other factors lead to a competitive situation, which requires companies to improve and adjust their product design, development strategy and development process. At the same time customers demand for shorter product development times and lower prices. Under such challenging circumstances, companies still must remain innovative to ensure future success, which leads to contradictory requirements. Therefore, companies need to increase the efficiency and effectivity of their innovation process [Boone 2000].
A promising approach is Lean Innovation, which means that Lean Thinking is applied to innovation processes [Schuh et al. 2008a]. Many publications use the term Lean Product Development but to be a successful company, Lean Thinking should also be applied to the innovation process of a company [Gudem and Welo 2010]. Thus, this paper uses the term Lean Innovation to highlight the importance of a more holistic application of Lean Thinking.
In general, Lean Thinking is a system of principles and methods [Warnecke and Hüser 1995]. The core principles are to create customer value, avoid waste, establish flow in processes, and strive for continuous improvement. The Lean Thinking principles are on a rather abstract level. Lean methods help to make the principles more tangible and applicable in industry context. At first, Lean Thinking was applied mostly to production processes, which is called Lean Production. Different studies revealed the effectiveness of Lean Production to increase the efficiency and effectivity. However, many companies optimized their shop floor so that further improvements are more difficult to achieve.
Accordingly, the interest in applying Lean Thinking shifted towards the innovation process because the development of new products plays an central role for the competiveness of companies [Morgan 2006]. Nevertheless, it is important to mention that Lean Innovation does not per se lead to improvements since its implementation requires a new way of thinking [Karlsson and Ahlstrom 1996]. Different case studies exist that describe the process of implementing Lean Thinking [Womack and Jones 1996], [Czabke et al. 2008]. The case studies show that employees are an important enabler for a successful Lean transformation. Common barriers for an implementation are a traditional mindset of the involved employees and communication. Besides the human factor, the innovation process itself makes an implementation challenging because it is creative process with uncertainty, dynamic interaction, and high complexity [Schuh et al. 2008b]. Accordingly, is should be investigated how Lean Innovation influences processes and people to further improve their design and application.
This paper aims to contribute to the understanding of challenges that arise when Lean Innovation is implemented. The authors therefore conducted an empirical study within a student project in order to reflect and analyse the problems that occur when Lean methods are introduced and applied.

2. Theoretical background

2.1 Definition of innovation

The term innovation is often understood in different ways, which is highlighted by the different definitions in literature (e.g., Sehested and Sonnenberg 2011). The term innovation is defined in this paper through following key words: creating value by solving the customer's problems, being new and feasible. Feasibility was added because an innovation should not only be new and potentially value creating but also feasible. From a process perspective, innovation differs from development because developments happens in an environment of higher certainty. Speaking of development in this paper means: a first concrete practical application of an idea (e.g., the construction of components).

2.2 Lean Thinking

Perhaps the best description of Lean Thinking in one sentence is: "It is an endless journey of improvement" [Liker and Morgan 2006]. The focus lies on creating customer value, identifying and eliminating waste. Five principles describe the core values of Lean Thinking: The customer should be able to control what (*customer value*) has to be produced and when (*pull*). The production processes should be standardised and executed steadily (*flow*). During this flow the customer's value should increase constantly without producing waste (*value stream*). Every involved person should strive for perfection (*perfection*) [Womack and Jones 2013]. Lean Thinking (Toyota Developing System) was also applied to development departments, which is forms the cornerstone of Lean Innovation [Sehested and Sonnenberg 2011].

2.2.1 Lean Innovation

While in Lean Production the focus is on the flow of materials, in Lean Innovation the flow of information becomes most important. Material, equipment, and production processes are replaced by people, knowledge and relations [Sehested and Sonnenberg 2011]. The innovation process takes place in the people's heads. The aim is now to work efficiently with knowledge and information.
The seven principles for Lean Innovation are analogous to Lean Production [Sehested and Sonnenberg 2011]:

1. *Gemba* is a Japanese word that describes sharing information by meeting at the real place.
2. *Front Loading* means shifting more resources to early stages of an innovation process, where the majority of the costs are determined. The aim is to gain more knowledge in this stages in order to make better informed decisions.
3. *Visual Management* means that communication should always be done visually, because information can be gathered more easily this way. Presentations should be made only for external use, because the required effort is not necessarily value creating
4. *Timeboxing* - Addresses the importance of setting a deadline. The objective is to achieve maximum success in a previously defined time by making great efforts and not to achieve maximum success in any amount of time. This helps to finish pre-set goals on time.
5. *One piece flow* means a batch size of one in production context. In the context of Lean Innovation it means working on one task at the same time and finish it before starting another instead of leaving a lot of tasks unfinished.
6. *Takt* is a German word describing the time a worker has at his assembly station to complete his work. This time should be quite constant. As in production processes, workloads should also be evenly distributed in innovation processes to let work flow.
7. *Prototypes* are very powerful in testing assumptions and concepts. They also visualise ideas and speak the language of the prospective users. They should not show what is technologically possible, but generate knowledge fast and cheaply.

For the implementation of Lean, methods are needed because the principles provide no instructions.

2.2.2 The role of methods in Lean Innovation

In general, methods contain instructions how to reach a certain objective and are described by the

following characteristics: rule-based approach, solution-oriented, modular and operational character [Lindemann 2009]. Dombrowski and Zahn [2011] developed a Lean framework for development processes, which is depicted in Figure 1 and can be used for an innovation process. The development and the innovation process both ensures the company's goals. Methods and their tools support the development process to achieve the goals. Methods and tools can be assigned to principles according to their purposes and attributes, which illustrates how Lean methods support the innovation process.
Applying Lean Thinking offers a lot of advantages: improving a company's competitive position by shorter product development and faster time to market [Karlsson and Ahlstrom 1996]. Lean Innovation methods support the implementation by giving clear instructions to change long-established working methods.
Another problem is the high uncertainty and thus a low predictability of innovation processes [Schuh et al. 2008b]. In contrast to a production process, an innovation process is not repeatable. An innovation is, by definition, something completely new and has never existed before. So each process is unique as well, which makes it much more difficult to understand the complex system of an innovation and its process. Tasks are strongly linked with each other, which leads to a more challenging identification of value creating tasks and waste. In such a situation methods can support users by dividing the system and thus reducing complexity. Furthermore, Lean Innovation methods help to make an innovation process efficient by translating the abstract principles into specific instructions. Overall, methods support applying Lean Thinking by changing the way of thinking, reducing complexity and translate the Lean Principles into instructions. Thus, methods can also be called the key to Lean Innovation.

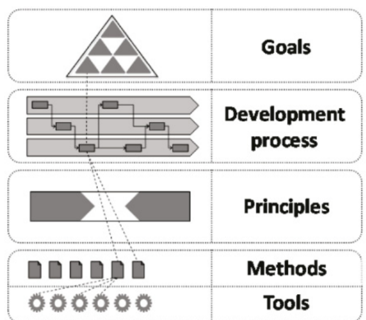

Figure 1. Role of methods in a development process [Dombrowski and Zahn 2011]

2.2.3 Challenges in implementing Lean Thinking in industry

Applying Lean Thinking can lead to competitive advantages, but the implementation requires wide organisational changes in terms of behaviour and methods [Baines 2006]. Different publications exist that summarize the findings of case studies concerning the implementation of Lean Thinking in different sectors (e.g., [Karlsson and Ahlstrom 1996], [Browning and Sanders 2012]). A common finding of these case studies is that implementing Lean Thinking leads to organizational problems because becoming lean requires a novel way of thinking and problem solving. The implementation of Lean Thinking also bears a risk because the organizational problems might overrule the benefits [Radnor and Boaden 2004]. In order to avoid problems related to the implementation of Lean Thinking, communication within the organisation is crucial to ensure that the employees understand the new way of thinking and accept it [Czabke et al. 2008]. The employees are therefore a crucial factor for a successful implementation. Organizing workshops and meetings for employees is thus essential for becoming lean. Additional empirical studies on a detailed level are need to further advance the understanding [Hoppmann et al. 2011].

3. Need for further research

3.1 Difficulties in the practical application of Lean Innovation methods

The shop floor is often already "lean" [Hines et al. 2004], this transition is still in progress for R&D departments [Schuh et al. 2008b]. Different case studies exist, which describe the overall process of

implementing Lean Thinking in organizations. A common finding was that becoming lean is quite a challenging path because it requires also organizational changes.
However, Lean Thinking is a system that consists of many methods, which help to anchor the Lean Principles in an organization. Most of the case studies describe the general process of implementing Lean Thinking without focusing on certain methods in detail. Methods are a cornerstone for the implementation and at the same time it also became clear that the willingness and ability of employees to change is an important enabler for a successful journey to become lean.
The derived research question is therefore: What are the problems linked to the human factors that occur during the implementation of a selected Lean Innovation method? Accordingly, the objective of this paper is to contribute to the in-depth understanding of effects and problems that are linked to an implementation of Lean Innovation methods. It is especially of interest to gain empirical insights how people deal with methods if they are new to Lean Thinking.

3.2 Research approach

A theoretical explanation of many Lean Innovation methods is available in literature. However, in-depth empirical results are not available for the implementation of methods. Based on these insights the objective is to derive suggestions how the application of the selected methods could be improved.
Therefore, the objective of this work is to apply selected Lean Innovation methods in a student project in order to gather additional empirical insights about the problems that occur during the implementation. Graduate Engineering students unexperienced with Lean Thinking are a good representation of employees without Lean experience because they receive the general engineering education. Nevertheless, they also miss working experience what might lead to other problems.

3.2.1 Introduction student project Massageboy

In 2015, the Institute of Product Development offered a development project that allowed graduate students to work on a defined design task for six months. The task was to first develop an idea of an innovative mechatronic product and secondly to turn this idea into a functioning demonstrator. The student team consisting of five students with mechanical engineering and computer science backgrounds decided to develop a massage robot. The students were supervised by research assistants. One of the authors was part of the student team and besides working on the design task, he was also responsible for the selection, integration and evaluation Lean Innovations methods during the project.

3.2.2 Developed Research Methodology

The Design Research Methodology (DRM) served as a methodology blue print for this work [Blessing and Chakrabarti 2009]. The four general stages (Research clarification, Descriptive study I, Prescriptive study and Descriptive study II) of the DRM are depicted in the upper part of Figure 2.

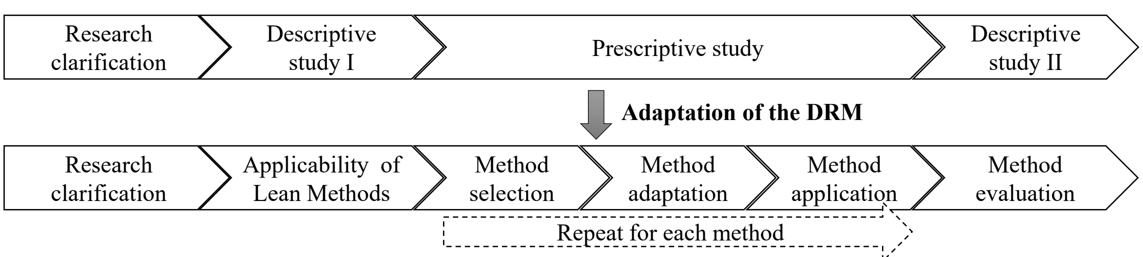

Figure 2. Developed Research Methodology for the application of the Lean Innovation methods

In general, the DRM offers a suitable framework for the development of a specific methodology. Due to the generality of the DRM, the authors decided to adjust the DRM to their research objective. The focus on method application draw the attention to the Munich Model of Methods (MMM) [Lindemann 2009]. The MMM aims to support practitioners in applying methods during the design process and consists of four steps: Clarification of method application, Method selection, Method adaptation and Method application. The Descriptive study I starts with a comprehensive study of the existing body of knowledge about Lean Innovation methods and the clarification of its application. The last three steps of the MMM correspond with the Prescriptive study phase of the DRM because during these steps, methods are applied in order to overcome identified challenges. Therefore, the decision was to integrate those three steps in the DRM. The Descriptive study II requires an evaluation of the applied methods concerning the usefulness and applicability. The step is essential to identify problems related to the application of the Lean Innovation methods and to formulate recommendation for the application of the selected methods in the future. All steps of the developed research methodology are depicted in the lower part of Figure 2 and were applied during the case study.

4. Application of the Lean Innovation methods

While working on the project different problems appeared. Some of them were of a technical nature while others were organisational challenges. During the research clarification a comprehensive search for existing Lean Innovation methods was carried out literature based. The outcome was a list with available methods and a corresponding description. As soon as a problem occurred during the student project, the list was consolidated to identify suitable Lean Methods. The applicability of a method was evaluated in a first step based on the required inputs. In a second step a comparison of the desired and provided output was conducted. The selection of the Lean Innovation methods therefore happened problem driven and the crucial aspect for a selection was the assumed ability to solve the problem.
Over the course of the project in five Lean Innovation methods (Last planner system, Visual Project Board, Front Loading, Set Based Engineering, and Learning Cycles) were implemented. In the following two methods are presented in detail: the Visual Project Board (VPB) and Learning Cycles (LC). The first one addresses the project management and the second one the creative solution finding process. The decision was to summarize the gathered insights concerning those two methods because both were implemented early on during in the project and therefore lead to more detailed insights.

4.1 Virtual Project Board (VPB)

Problem description

The Massageboy team started with a SCRUM Board to organise its design task. A Scrum Board consists of three columns: work TO DO, WiP (Work in Progress) and DONE with a row for each team member. The result is a matrix, in which the tasks for each member are fixed by sticky notes considering the task's progress. This kind of board is often used during agile software development. In such projects the planning horizon is shorter than in projects with hardware components, like the Massageboy project. At the beginning this seemed not to be a problem, but with time passing by the team lost its purposefulness. With a planning period of one week, it was hard to keep the superior goals in mind and work consequently towards them.

Method description

In order to deal with this organisational problem, the team decided to try out the Visual Project Board (VPB). Originally this method is presented by Sehested and Sonnenberg [2011]. Like on the SCRUM board, sticky notes are used to assign tasks to the members. But the planning period is longer – in this case 6 weeks. The team holds its meetings weekly so the work packages have to be on a weekly basis.
Furthermore the VBP follows several Lean Principles from Section 2.2.2:

- Gemba: All members go to the board, which is located on a fixed place, and fill it out together
- Visual Management: The board's fields are designed such that information can be gathered immediately
- Timeboxing: Tasks are clearly distributed and terminated so that the members are encouraged to finish their tasks on time
- One piece flow: The worker always knows which task has to be done and therefore knows how long he can fully concentrate on this task without neglecting other tasks.
- Takt: by assigning tasks with sticky notes, accumulation or idle can be identified and fixed

Method adaption

The VPB only required a few changes, but it is important to design it individually, in order to enlarge the identification with the project. The VPB that was designed for the Massageboy team is depicted in Figure 3. It consists of the boxes for objectives, success criteria and project deliverables on the left; Key Performance Indicators (KPIs), ideas, risks and actions on the right hand side and the task matrix with the members' names in the middle of the VBP. Risks and ideas can be instantly classified regarding to consequence and probability of occurrence or to benefit and effort respectively.

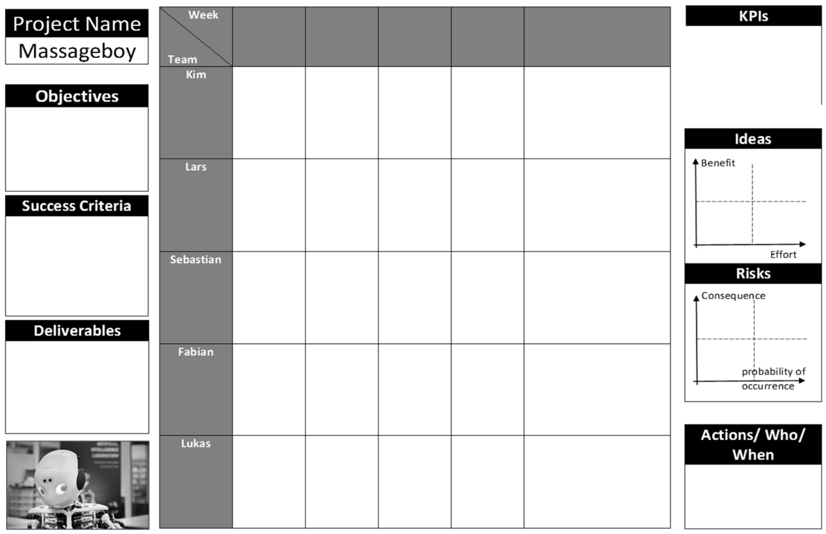

Figure 3. Visual Project Board adapted to Massageboy project

Method application

The application of the method has been standardised in six steps. The first four steps describe the initialisation of the board, the fifth how meetings are held and the sixth how it is re-planned:

- Defining the project goals (Objectives; Success Criteria; Deliverables) - Answers to the questions: "Why did we start the project?"; "How do we measure whether it is a success?"; "What should the project deliver when we have finished it?"
- Planning the project - Which milestones are necessary to achieve the goals? To determine those milestones and their order, another method can be used. The Massageboy team uses a self-adapted version of the Look Ahead Plan from the Last Planner System [Ballard 2000]. The members then discuss when they need information from each other and consider it while setting the tasks in the matrix.
- Defining the KPIs - The team choose the KPIs by itself. They have to discuss what is important for them during the project (e.g. satisfaction of all members in [%]).
- Recognize risks for the project - Different methods like FMEA can be used to identify risks. More important is that these risks are written in the board, so that they are visible.
- Meetings - are held weekly and thus ensure a continuous feedback. Through the common discussions the members get to know results and problems of the tasks. The meetings should take place in a standardised manner: 1. Discuss actions since the last meeting 2. Discuss finished and future milestones 3. Update the KPIs 4. Evaluate risks and collect ideas of improvement 5. Sum up the meetings and define new actions if necessary. For specific technical discussions between several members, either the whole team allows the discussion or the discussion has to be postponed [Sehested and Sonnenberg 2011]. If tasks cannot be fulfilled, they will be marked with a red dot for each week they are delayed. Problems can be identified instantly.
- Replanning - When the time has passed the planning period, here six weeks, the board has to be re-planned. Objectives, success criteria and deliverables can be re-evaluated. Thereby the

project progress can be detected and evaluated. The main task is the planning of the future milestones (step 2. Planning the project)

4.2 Learning Cycles (LC)

Problem description

From the beginning the team decided to work in an iterative process. They started with the "Lean Start Up" approach from Ries [2011]. "It favors experimentation over-elaborate planning, customer feedback over intuition, and iterative design over traditional “big design up front” development." [Blank 2013]. The team's problem was that they started, as recommended, early with prototypes and tested their concepts. Riskiest assumptions should be tested first. The intention of this idea is logical and promising, but the adaption to this project revealed some disadvantages. Encouraged by the call for early prototypes, they started without knowledge about possible customers and their needs. They began quickly, just to realise something as soon as possible. It was not sure that the prototype will really have value for the project. Some more guidance was necessary to work more efficiently.

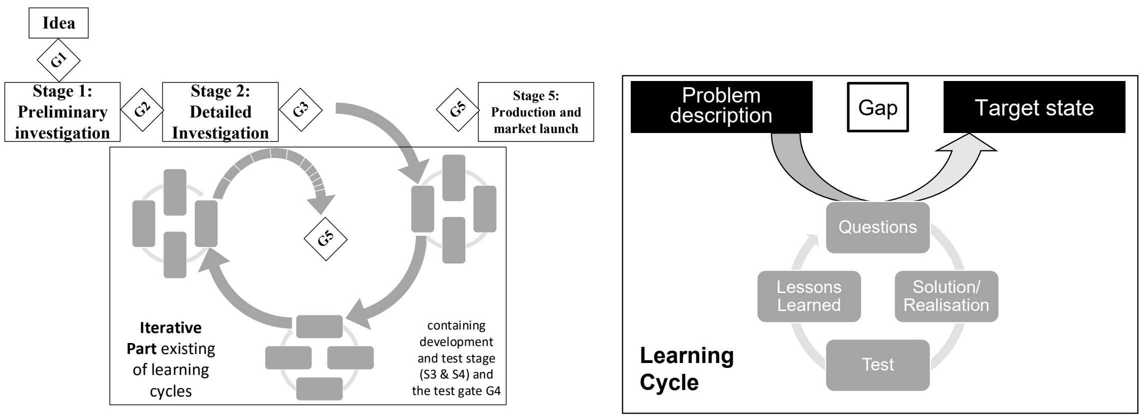

Figure 4. Iterative Innovation Process (left) & Learning Cycle for the project (right)

Method description

The basic idea originates from Schipper and Swets [2010]. The approach consists of strict rules and five clearly defined steps: Plan, Design, Build, Test, and Review. Each step has sub steps, which give instructions to the user. Early prototyping (Lean Principle: Prototyping), like in the "Lean Start Up" approach is a central aspect, but the approach is much more structured. If prototypes are only built when development has been finished, like in the classic Stage-Gate-Process [Cooper 1990], a chance for early feedback is lost. With prototypes and their testing with customers, a customer-orientated development is ensured (Lean Principle: Gemba). A late determination of the design allows riskless changes with smaller change costs. Furthermore, a team should work together on a solution for one problem, so that creativity and knowledge is bundled (Lean Principle: One piece flow).

Method adaption

An adaption was necessary because the original process, presented by Schipper and Swets [2010], is very detailed and its steps (Plan, Design, Build, Test, and Review) are elaborate. In the Massageboy project, the aim was to apply a more simple process that is both goal oriented and leading, so the users can focus on innovations because of a standardised approach but do not get too busy working just for the approach itself. For the Massageboy project the innovation process (see Figure 4, left) was adjusted and the so called Learning Cycles (LC) were established (see Figure 4, right).
The innovation process is a mixture of a Stage Gate Process from Cooper and an iterative part existing of Learning Cycles. They are repeated as long as the solution converges against the requirements at Gate G5 (c.f. [Cooper 1990]). During an LC at first the problem and the target state have to be described. Between those two states there is normally a gap, which has to be filled in order to solve the problem.

Therefore, the occurring questions are formulated, a solution is developed and tested against formulated criteria. The experiences are documented and either lead to new questions and a new cycle or to the fulfilment of the requirements of the target sate. The LCs can be understood as a mixture of the Build Measure Learn Cycles from Ries [2011], which were too unstructured for the team, and the strict approach of Schipper and Swets [2010]. This new Learning Cycle is fitted in an innovation process, which supports the approach of iterative learning (c.f. Figure 4, on the left side).

Method application

During the application, the determination and documentation of objectives, questions, success criteria, measurement methods, and probable resources before starting the cycle is fundamental. Also the documentation of gathered knowledge and occurred problems at the end is very important. In order to ease this process, a standardised document was developed. It contains the title of the cycle and its number (sub-cycles for sub-problems can easily be identified by using chapter and section numbers). Furthermore, the planned time period for the cycle is documented as well as the points described above. They are written in key points, which helps the user to complete the documentation fast and to focus on the key task - finding a solution. The uniform style of those documents supports the re-use of information, because the users know exactly where they can find key information. It is important to start with the riskiest assumption and parts of a concept - otherwise it could fail after spending too much time for it.

5. Evaluation of the Lean Innovation methods

5.1 Visual Project Board (VPB)

The team's acceptance for this method was very high. As they had in mind the disadvantages of the old system, the motivation for trying a new one was high. With the use of the VPB a lot of improvements came along for the team: the roles within the team become clear, the specification of the tasks for a period of six weeks ease to reach the milestones (people prefer tasks which are both urgent and well-specified), the sense of responsibility is enlarged by the visual representation of the own milestones, the process of planning the board requires a proactive participation (which increases the identification with the project), participants do not forget the project's big picture by having the objectives and deliverables in front of them. The VPB also encourages a focused way of work, the KPIs help to continuously monitor the project and support improvement.

The visualisation of risks and ideas helps to keep them in mind every time the user looks at the board. Standardised meetings help to focus on the important things, like problem-solving and creativity. Through the visualisation of the tasks with sticky notes everybody can recognize immediately who needs which information at what time. The definition of objectives is important because by agreeing on such, the power, ideas and motivation of all members are concentrated and increased.

These advantages can only evolve completely, if the board exists physically. In this project a virtual version did not work, because it was not maintained well enough. Adding the field "Chances", as a preliminary stage before "Ideas", would additionally support creativity because possible fields of discovery are shown. A problem during the project was to hold the meetings regularly and in a standardised way. Many times the team interrupted the meeting process and started to work on certain topics and thus neglected maintaining the board properly. Possible solution are: adding a KPI for finishing the meeting successfully, elect a person who is allowed to interrupt discussion and take care of the meeting-process or the team defines an own process together and place it, visibly for everybody, next to the board. This can support the regularity, which is necessary for this method.

5.2 Learning Cycles (LC)

The application of LC was more challenging because it requires to change the thinking to pragmatism. It is important to make functional prototypes and get them tested - if possible together with a potential user. At the Massageboy project the team built functional, cheap prototypes, often simply made of wood, and went to public places or to massage studios and tested them with the people there. That way fast feedback can be gathered without making great efforts. The team got valuable information from both potential customers and professional buyers. Problems with concepts can be revealed early and potential customers and buyers can communicate their needs and requirements. But therefore the members should not hesitate to show simple constructions. This helps innovations to face uncertainty and be flexible to changes in the customer's wishes. Sometimes those wishes cannot be revealed until they see a prototype. Furthermore, enough time has to be reserved for discussions of results and problems of a finished LC. Experiences in this project show that this is often done quickly and the team moves on to possible solutions without a proper discussion of the gathered information. To gain knowledge, discussions, and communication are fundamental and often need some extra time, so buffer in meetings should be considered.

Another difficulty is the discipline concerning standardisation. This is important because only re-used information is value creating. Therefore, standardisation has to be done very carefully, e.g. with standardised lists. Standardisation is also the basis for the solution-oriented working. The clear procedure of the LC helps the user to work to an aim, which is defined at the beginning, and be creative as well. The user of the LC knows the gap between the problem and target state, which has to be filled and has the absolute freedom to fill it the way he wants to. This thinking encourages innovations, because it does not start with existing solutions but with an exact description of problem and target state. Leaps in finding a solution become easier because thinking is not bound to existing solutions. The way a solution looks like is not defined by the process, but only the way to get there. The user hardly can do anything wrong as long as he has the right aim in mind.

6. Summary and outlook

Companies are facing are manifold and contradictory challenges because products need to be more innovative, of higher quality, and have a low price. A promising approach is Lean Innovation, which supports companies in becoming more efficient and effective. However, the Lean Innovation principles are formulated on an abstracted level and therefore, cannot be implemented easily. The gap is closed by Lean Innovation methods, which allow to incorporate the principles in the innovation process. Even though, the methods are meant for practical experience most of the methods are only described theoretically and their application is not studied empirically. The analysis of published case studies revealed that the human factor is a critical success factor for the implementation of Lean.

This work aims to contribute to existing knowledge about Lean Innovation methods by conducting an empirical study during a student design project. The main interest was to investigate, which problems occur during the implementation and how Lean Innovation methods can be improved. Based on the problems that the students faced during the project, the VPB (a board with sticky notes for project management) and LC (short cycles that allow for fast feedback and learning) were selected and implemented. For the empirical evaluation of the methods, the authors developed a methodology that at first gathers all available methods from literature and then analyses them theoretically. Afterwards, a suitable method is selected opportunity-driven and adapted to the project needs. The application is followed by an evaluation to further improve the methods. The authors believe that the developed approach is also suitable for the introduction of new methods in real projects.

The results of the empirical study emphasize that implementing methods requires strong leadership because people need to change their working patterns and thinking. The methods itself are not that difficult but the resistance of the involved people is difficult to overcome. It is therefore crucial that the methods are integrated well in the existing processes and that the application is standardized. The study showed that the application of the Lean Innovation methods supported the students well in achieving their project objectives due to a better planning, communication, and faster leaning cycles.

The application of Lean Innovation methods promises new stimuli for innovation processes. Nevertheless, more empirical research is required. A next step can be to implement Lean Innovation methods in larger projects with more experienced people and again investigate the occurring problems.

References

Baines, T., Lightfoot, H., Williams, G. M., Greenough, R., "State-of-the-art in lean design engineering: a literature review on white collar lean", Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, Vol.220, No.9, 2006, pp.1539–1547.

Ballard, H. G., "The Last Planner System of Production Control", The University of Birmingham, Doctor Thesis, 2000.

Blank, S., "Why the lean start-up changes everything", Harvard Business Review, Vol.91, No.5, 2013, pp.63–72.

Blessing, L. T., Chakrabarti, A., "DRM, a Design Research Methodology", Springer London, London, 2009.

Boone, J., "Competitive pressure: the effects on investments in product and process innovation", The RAND Journal of Economics, 2000, pp.549–569.

Browning, T. R., Sanders, N. R., "Can innovation be lean?", California management review, Vol.54, No.4, 2012, pp.5–19.

Cooper, R. G., "Stage-gate systems: a new tool for managing new products", Business Horizons, Vol.33, No.3, 1990, pp.44–54.

Czabke, J., Hansen, E. N., Doolen, T. L., "A multisite field study of lean thinking in US and German secondary wood products manufacturers", Forest Products Journal, Vol.58, No.9, 2008, p.77.

Dombrowski, U., Zahn, T., "Design of a lean development framework", IEEE 2011. ISBN: 1457707403, 2011.

Gudem, M., Welo, T., "From lean product development to lean innovation: finding better ways of satisfying customer value", New World Situation: New Directions in Concurrent Engineering, Springer, 2010, pp.347–355.

Hines, P., Holweg, M., Rich, N., "Learning to evolve: a review of contemporary lean thinking", International Journal of Operations & Production Management, Vol.24, No.10, 2004, pp.994–1011.

Hoppmann, J., Rebentisch, E., Dombrowski, U., Zahn, T., "A framework for organizing lean product development", Engineering Management Journal, Vol.23, No.1, 2011, pp.3–15.

Karlsson, C., Ahlstrom, P., "The Difficult Path to Lean Product Development", Journal of Product Innovation Management, Vol.13, No.4, 1996, pp.283–295.

Liker, J. K., Morgan, J. M., "The Toyota Way in Services - The Case of Lean Product Development", Academy of Management Perspectives, Vol.20, No.2, 2006, pp.5–20.

Lindemann, U., "Methodische Entwicklung technischer Produkte - Methoden flexibel und situationsgerecht anwenden", Springer, Dordrecht u.a., 2009.

Morgan, J. M., Liker, J. K., "The Toyota product development system", New York, 2006.

Radnor, Z. J., Boaden, R., "Developing an understanding of corporate anorexia", International Journal of Operations & Production Management, Vol.24, No.4, 2004, pp.424–440.

Ries, E., "The lean startup - How today's entrepreneurs use continuous innovation to create radically successful businesses", Crown Business, New York, 2011.

Schipper, T., Swets, M., "Innovative lean development - How to create, implement and maintain a learning culture using fast learning cycles", CRC Press, Boca Raton, Fla., 2010.

Schuh, G., et al., "Lean innovation: introducing value systems to product development", Schuh, G. (ed.); Lenders, M. (ed.); Hieber, S. (ed.), IEEE 2008. ISBN: 1890843172, 2008a.

Schuh, G., Eversheim, W., Jung, M., Lenders, M., Schöning, S., "Lean Innovation–ein Widerspruch in sich?", Business Excellence in technologieorientierten Unternehmen, Springer, 2008b, pp.13–20.

Sehested, C., Sonnenberg, H., "Lean innovation - A fast path from knowledge to value", Springer, Berlin, 2011.

Warnecke, H.-J., Hüser, M., "Lean production", International Journal of Production Economics, Vol.41, No.1, 1995, pp.37–43.

Womack, J. P., Jones, D. T., "Beyond Toyota: how to root out waste and pursue perfection", Harvard Business Review, Vol.74, No.5, 1996, pp.140–158.

Womack, J. P., Jones, D. T., "Lean Thinking - Ballast abwerfen, Unternehmensgewinn steigern", Campus Verlag, Frankfurt am Main, 2013.

Julian Wilberg, Research Assistant
Technical University of Munich, Institute of Product Development
Boltzmannstr. 15, 85748 Garching, Germany
Email: wilberg@pe.mw.tum.de