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The Toyota Kata Approach for Lean Product Development

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Abstract. There are several benefits reported in literature related to the adoption of lean in development environments, as rework reduction, innovation and an increase in value adding. However, there is a few literature regarding how to manage uncertainties, to integrate developers, to maximize the knowledge sharing and minimize its losses in a lean product development environment. The Toyota Kata approach enables the establishment of management routines that can conduct the development process, deal with uncertainties, stimulate organizational learning and integrate and align all development team towards the development goals. This paper aims to demonstrate how the Toyota Kata approach can be used in a Lean Product Development environment and to present the initial results of its application in the development of an innovative product, a magnetic refrigerator. Initially, a literature review was performed. Then, a model for Toyota Kata in Lean Product Development environments was developed. Finally, an action research was performed in the development of the product of a magnetic refrigerator. As a result, an increase in integration, value focus, alignment towards development goals and knowledge sharing was observed. The Toyota Kata approach provided a management routine that enabled daily management of lean product development. Also, it contributed to reduce the risks associated with product development.

Keywords. Toyota Kaya, lean product development, magnetic refrigeration, set-based concurrent engineering

Introduction

The benefits reported in the literature regarding the Lean Product Development (LPD) are lower development costs, lower lead times, better quality, rework reduction, innovation and an increase in value adding [1], [2], [3]. However, there is an absence of management techniques regarding the LPD. The development process is full of uncertainties that have to be controlled in order to achieve the development goals on time, costs and results. However, there is a few literature regarding how to manage those uncertainties, to integrate developers, to maximize the knowledge sharing and to minimize its losses in a development environment [3].

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The Toyota Kata (TK) approach proposed by [4], consists of two complimentary routines that, when repeated constantly, have the potential to make the continuous improvement part in the culture of the organizations. TK approach has the potential to enable the establishment of management routines that can conduct the development process, stimulate organizational learning and align all development team towards the development goals. Based on this scenario, this paper aims to demonstrate how the Toyota Kata approach can be used in a Lean Product Development environment and to present the initial results of its application in the development of a magnetic refrigerator.

First, we present the methodology adopted in this study. Then, the state of the art in LPD models and frameworks and in TK approach implementation is presented. After, we present the TK approach for LPD at the initial results of its application in a product development environment. Finally, we present the conclusions.

1. Methodology

First, an extended Structured Bibliography Research (SRB) was performed to gather information about the applications of Toyota Kata approach and LPD. Based on the SRB, the best characteristics and recommendations were selected to develop a model of application of the Toyota Kata approach in product development environments. Thus, in order to demonstrate the results of the use of Toyota Kata in product development environments, an action research was performed. Action research is a methodology in which the researcher plans, implements, describes and evaluates an improvement in a current practice in a specific environment [5].

The Toyota Kata approach was implemented in the first stages of the development of a magnetic refrigerator. During the action research, data were collected by direct observation and feedback interviews. Direct observation was performed through participation in meetings. Feedback interviews were constantly performed with the engineers who were involved in the product development. The focus of these feedback interviews was on their experiences when they compared the new approach with the previous way of working.

Finally, the collected data was analyzed by arraying the descriptive data in order to identify the results obtained after the implementation when comparing to the previous practices. The focus was on observed critical incidents as an indication of improvement or decrease in the performance of product development process.

2. Lean Product Development Models and Frameworks

LPD is the application of the principles of lean thinking in product development environments [3], [6], [7], [8]. Several authors proposed LPD models and frameworks over the years. The first theoric framework found was from [9], that affirmed that the LPD management practices could be grouped in six organizational mechanisms: integrated leadership, mutual adjustment, direct supervision, skills, processes and project padronization. [10] proposed a framework for LPD with 13 elements based on a people, process, tools vision. Among these elements, are the padronization to reduce variation and create flexibility and predictable results, develop a chief engineer to integrate the development from the very beginning until the end, balance and development technical and functional skills and build a culture of continuous improvement and learning.

Source [11] pointed out five elements for LPD: Focus on value, the leadership of the designer of the system, Set-Based Concurrent Engineering (SBCE), cadence, flow and pull and responsible specialists team. [12] proposed a theoretical framework to organize knowledge in LPD with 11 elements, also pointing out the chief engineer, knowledge sharing and variation management as important for LPD. [13] developed the Lean PPD model with five elements: SBCE, development and planning focused on value, knowledge-based environment, continuous improvement culture and chief engineer.

Sources [14], [15], [16] proposed frameworks for the improvement of a traditional product development approach towards the LPD. The main contributions to practices and steps of the LPD environment were made by [17], that explained how the integration events are performed in LPD and [18], that affirmed that between integration events, the subsystems must develop learning cycles in order to achieve the integration events goals. Other authors like [7], [19], [20], [21] proposed frameworks with steps and phases of LPD. Another important contribution was made by [22] that developed a model for how to draw the trade-off curves, that are used in the SBCE process.

Integration and management are pointed out by many authors ([10], [12], [13], [17]) as fundamental for LPD, however, there is an absence in models and frameworks that demonstrate how to integrate and manage the development. [17] affirmed that this integration is performed by integration events, but few were explained of how the integration must occur in these events. Furthermore, how to manage those learning cycles performed by subsystems that [18] proposed remain as a non-solved question.

3. Toyota Kata approach implementation

The TK is an approach to manage, lead and develop people, that enable the improvement and adaptability, through the introduction of routines and habits ([4]). The approach consists of two complimentary routines: the Improvement Kata and the Coaching Kata. When these structured routines are practiced repeatedly, they form unconscious and natural behavior patterns that are continuous improvement and scientific thinking [23].

The Improvement Kata routine, as presented in Figure 1, begins by establishing the Challenge, which is a future condition that a process should achieve in a long-term. Then, the current condition of the process is analyzed. By comparing the current condition with the Challenge, an Target Condition that point towards the Challenge is set. The Target condition is an intermediary condition that the process must achieve in a not so long-term as the challenge. The Target Condition is pursued by overcoming Obstacles, that prevent the process to achieve the Target Condition. By achieving successive Target Conditions the process will achieve the Challenge.

There are several applications of the TK approach in different environments. [24] and [25] used the TK approach to implement Lean Construction. [23] combined the TK approach with TRIZ approach to develop a method for innovation. [26] applied the TK approach in logistics. [27] implemented the TK approach in management services. [28] proposed a model for the Single Minute Exchange of Dies based on the TK approach. [29] developed a model for quick setup of hospital beds with the TK approach. [30]

used the TK approach to develop a model for hospital beds management. [31] applied the TK approach to manage the discharge from the hospital process. Also, [32] used the TK approach to implement the Value Stream Mapping in an organization. Among the applications of the TK approach found, there was no application in product development environments.

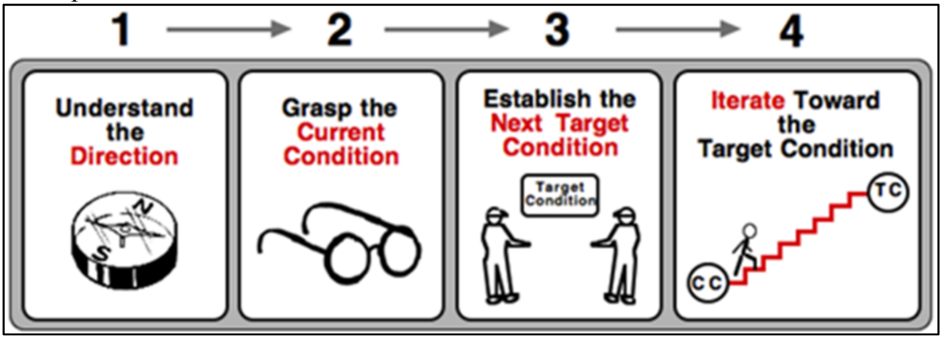

Figure 1. The Improvement Kata routine.

4. The Toyota Kata Approach for Lean Product Development

In product development environments, the two routines for Toyota Kata approach as proposed by [4], stay the same. However, the focus of the process no longer relies on the process improvement, but knowledge gaining and learning about the product. The roles played by the Learner and the Coach in product development environment are represented in Figure 2.

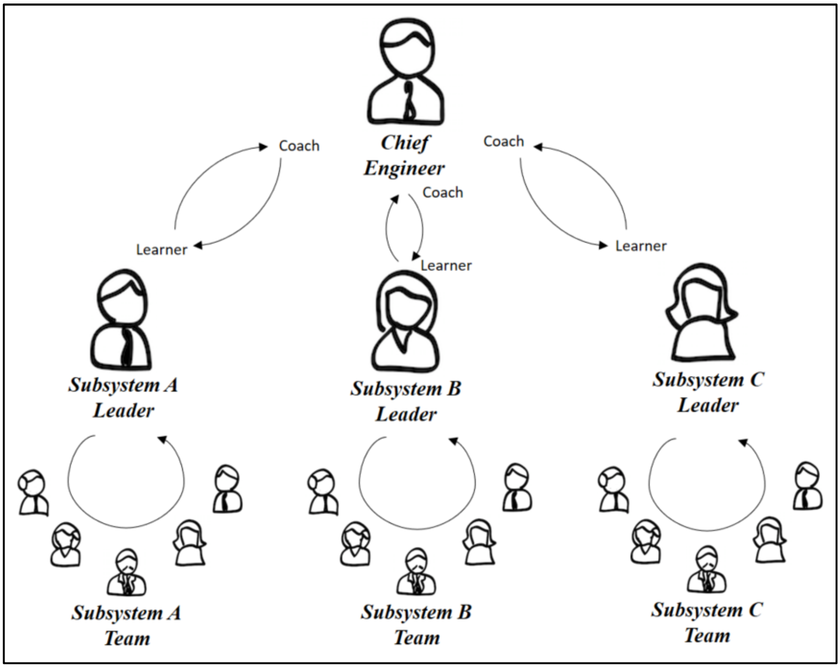

Figure 2. Roles in Toyota Kata approach for LPD.

The chief engineer plays the role of Coach while the leaders in the development team are the Learners. The chain of Coaches and Learners depends on the organizational structure of each product development. However, is important to assure that every developer acts guided by the Toyota Kata routines. In that way, all the development activities will be leading to the development goals achievement, reducing development risks and increasing integration and alignment.

In order to begin the Toyota Kata approach implementation in LPD, first, it is necessary to establish the Challenges. This is made in the initial phases of development when the value to the customer is studied and established through the use of matrixes and other tools. After the alignment and deep understanding of value among all developers, the chief engineer along with the subsystems understand the Final Challenge.The Final Challenge must be a declaration of a condition in which the product is finished and the performance and features desired by the final customer are achieved.

After the establishment of the Final Challenge, each subsystem will understand what they should deliver to the product and to the other subsystems in order to achieve the Final Challenge when the development is over. This is called the Final Subsystem Challenge. It is achieved at the end of the SBCE narrowing down process. In order to reduce development risks, it is recommended that more intermediate challenges between the Current Condition and the Final Subsystem Challenge are set. These are called Intermediate Challenges, which can be of one subsystem or between subsystems. It is important that the Challenges are written with as much quantitative and detailed information as possible. The Challenges in Toyota Kata approach for LPD are presented in Figure 3.

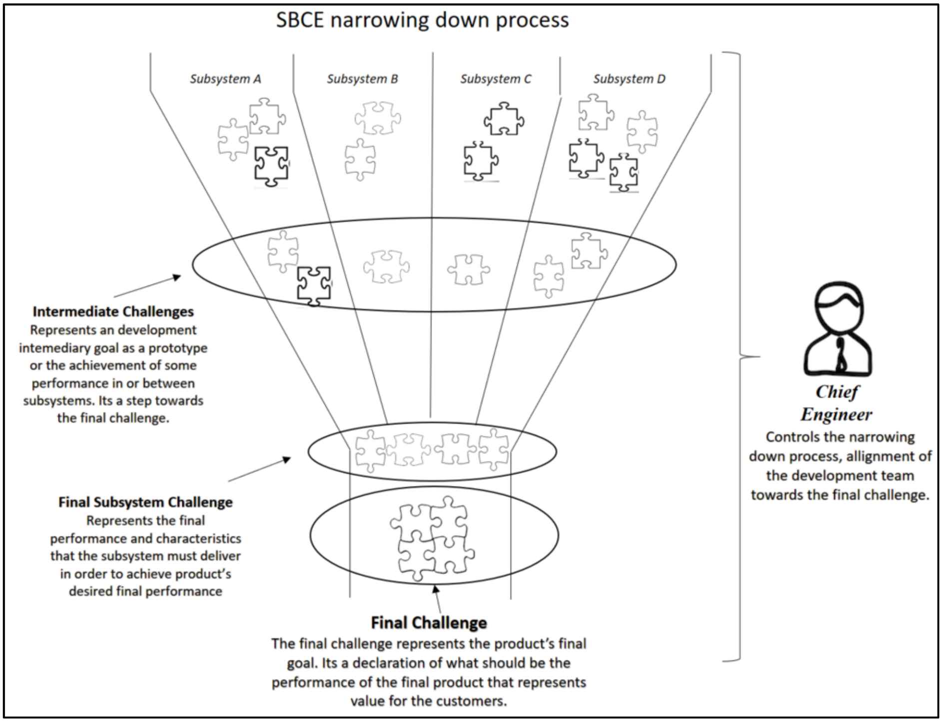

Figure 3. The Challenges in Toyota Kata approach for LPD.

When all subsystems understand and establish all Challenges that are necessary to the development, they analyze their current status of knowledge, technology, tools and resources and compare it to the next Challenge ahead. This is the understanding Current Condition phase in the Toyota Kata approach. By performing this reflection the subsystem is able to analyze the knowledge gaps, how much information they have about the product, and so on. With this background the subsystem establishes the next Target Condition, that is the condition it should be in a certain period of time in order to achieve the next Challenge according to the development deadlines. Finally, the subsystem can iterate in short PDCA cycles towards the next Target Condition. When the subsystem achieves the Target Condition, another Target Condition towards the Challenge is set. By repeating this process the subsystem reaches the Final Subsystem Challenge. These steps are shown in Figure 4.

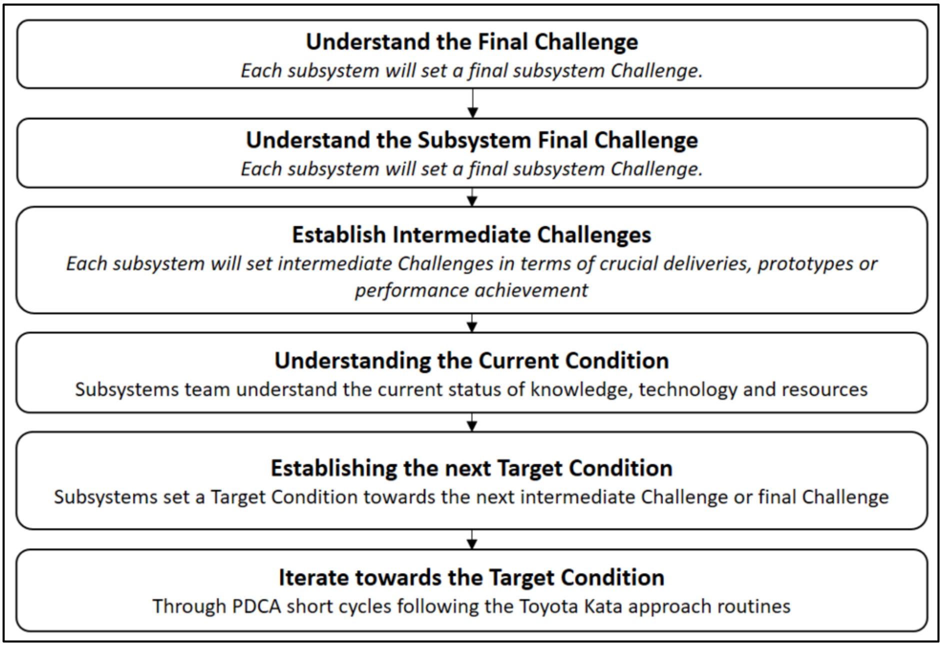

Figure 4. The Coaching Kata routine.

The narrowing down process in SBCE is performed by the subsystem as they gain knowledge. This is made by experiments in Toyota Kata approach short PDCA cycles. For this, it is possible for the chief engineer and all the leaders of the development to control the narrowing down process. All integration events, experiments, prototypes, trade-off curves drawing are planned, executed, controlled through the Toyota Kata routines. Since the development process is heavily based on learning, due to the storyboard concept, i. e., the record of all PDCA cycles, a robust structure of knowledge storage is created.

5. The Case of a Magnetic Refrigerator Development

The Toyota Kata approach was implemented during the initial stages of the development of a magnetic refrigerator. The product consisted of a technological innovation that uses the magnetocaloric effect to produce cold. This product was being developed by POLO (Research Laboratories in Refrigeration and Thermophisic) in the Federal University of Santa Catarina. Since it was an innovative product, the knowledge management, the innovation environment and the integration between subsystems were determining factors for the success of the development.

The development process was carried out according to the LPD principles. This process was started by dividing the product, as well as the developing team, into three subsystems: (i) integrated design of the active magnetic regenerator and magnet, (ii) hydraulic and control systems and (iii) cabinet and heat exchangers. To develop a magnetic refrigerator, the aforementioned subsystems must be designed integratively, sharing knowledge on every step of the process, as there was few knowledge about the application of this technology in a product previous to the beginning of the project. A cross-functional team was also created to focus specifically in the integration of the subsystems and their compatibility. The latter team was in charge of the outlook design requirements imposed by the customers as well as the overall performance of the product. The chief engineer was an experient researcher that had already developed a prototype using the magnetocaloric technology. The deadline for the project was four years.

First, the chief engineer established the Final Challenge for the product at the end of the deadline of the project, which described what the product should deliver to the customer after four years of development. Based on this Final Challenge, each subsystem leader, along with the other developers, established the Subsystem's Final Challenge, to be reached after the SBCE process. For instance, the final challenge of the subsystem of AMR and magnet integrated design was 'to develop a compact magnetic circuit that generates a magnetic field profile which enables to achieve the required operating point of cooling capacity and temperature span through an AMR filled up with magnetocaloric material'. Then, in order to reduce development risks, each subsystem defined an intermediate Challenge within the horizon of one year of development and each developer established its own personal Challenge. This process is illustrated in Figure 5.

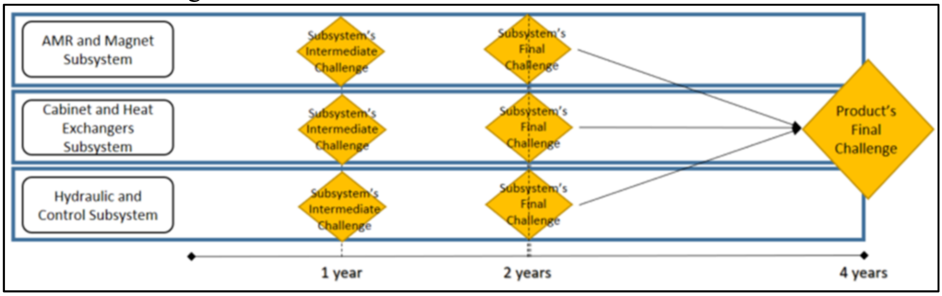

Figure 5. Challenges established in the project.

After all Challenges being established and the consensus was achieved, the Toyota Kata learning cycles begun by iterating toward the first intermediate Challenge. The chief engineer played the role of Coach and all developers played the role of Learners. This is due to the fact that each subsystem was composed by two to three engineers, then it was not necessary to attribute the role of Learner to a leader of the subsystem. The roles of Toyota Kata approach in this environment are presented in Figure 6.

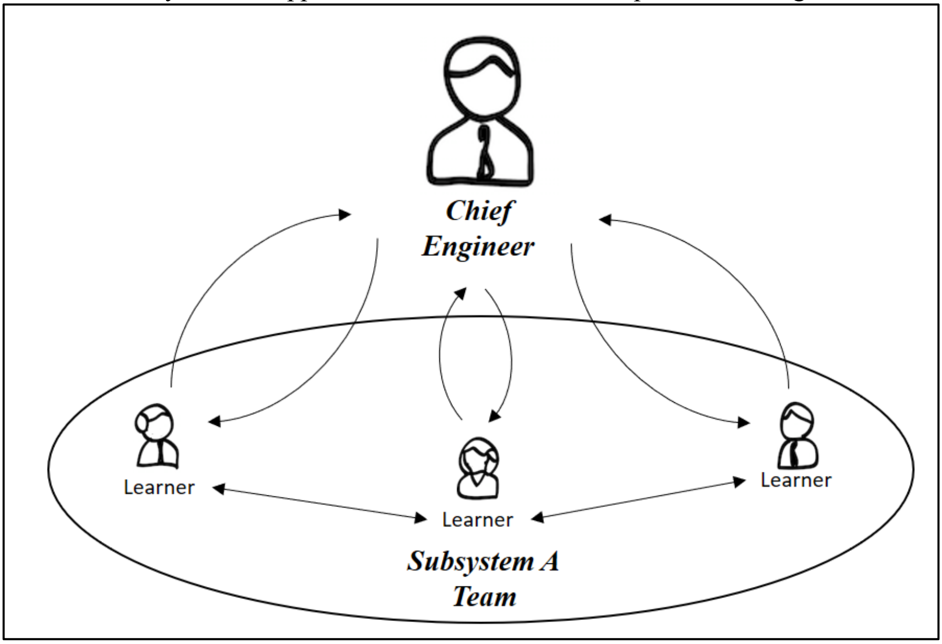

Figure 6. Roles of Toyota Kata approach in the application.

The Coaching Kata was performed by the chief engineer as the Coach. All developers of the subsystems participated in the same Coaching session, however, each developer had its own time presenting his PDCA cycle. All developers shared the same Challenges, however, they had not the same Target Condition, because each one of them worked in a different part of the subsystem. The Coaching session started by declaring the subsystem's Challenges. Then, the first developer presented its own personal Challenge, his Target Condition and reflected by his Current Condition. In order to achieve the Target Condition, the developer answered the questions associated with the PDCA cycles of Toyota Kata according to the model of [4]. After that, the other developers performed the same process.

6. Results and Discussion

The authors accompanied 33 Coaching sessions of Toyota Kata. It was observed that the chief engineer was able to guide the developers through the experiments, by suggesting some literature, tools and procedures. In fact, the chief engineers as a Coach cannot be restricted to a questioner, because in the product development environment, the expertise of the Chief engineer must be used to help the developers to achieve their goals.

The chief engineer reported that, with the Toyota Kata approach, he was able to know what every developer was performing, when and how this was aligned with the development goals. He also reported that it was easy to see what subsystems needed more focus and resources. According to him, the Toyota Kata approach provided a knowledge management structure that made the development management easier and more simple.

It was observed that the developer had no difficulty in performing the Toyota Kata approach routines and it had a high acceptance among then. They reported that the Toyota Kata structure of cycles record provided an organized source of information, since they could access it and easily find what they needed. It was also observed that the coaching sessions enhanced the integration among the developers of the subsystem.

The development risks were reduced since with the Toyota Kata approach, it was certain that every activity that every developer performed was aligned with the development goals. If they deviate from the path, it was easy to see and correct it. The coaching sessions happened once a week, so the maximum deviation a subsystem would have was one week. With the Toyota Kata approach, it was observed that the developers started to think about how what they were doing would make them achieve their Challenges.

7. Conclusion

We conclude that the Toyota Kata approach provides a managing structure that enables the alignment of developers, integration, reduction of development risks and knowledge management in the LPD environment. For future works, we recommend the application of the Toyota Kata approach in other phases of LPD, as the SBCE, for example. We also recommend the application of the Toyota Kata approach in different development environments.

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