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Towards effective Lean QRM Yellow-belt training programs: a longitudinal analysis

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Abstract. This paper studies the effect of Lean QRM Yellow-belt training programs on employee's continuous improvement (CI) behavior. Training employees is still the most common approach organizations follow to implement Lean production. However, such training programs do not always have the desired effect. To understand why Lean training programs, such as the Lean QRM Yellow-belt training may or may not lead to expected results, this study draws on a process model to conduct a longitudinal analysis. The results indicate that the Lean QRM Yellow-belt training program positively influences the patterning or shared understanding of lean operating routines, but does not (yet) influence the enactment of lean operating or CI routines. The interaction between enacting and patterning lean operating and CI routines however is necessary to implement lean production and thus influences the potential success of its sustainable implementation. These results pose practical implications on the content and didactical form of teaching in Lean QRM Yellow-belt training programs .

Keywords: Routines, Lean, Yellow-Belt, Training Programs.

1 Introduction

Lean production is a business philosophy focused on shortening lead times by removing waste and focusing on value-added processes. Lean production consists of lean operating routines (actual day-to-day activities) and continuous improvement (CI) routines (improvements on lean operating routines). Lean production is implemented successfully when it fosters a learning culture in organizations with the focus on continually improving all aspects of the organization. On the long run, Lean production supports companies to achieve incremental growth. For these reasons, Lean production has become a key business strategy that many companies are attempting to implement. In order to implement Lean production, organizations take different approaches, such as hiring consultants and training employees. However, while some companies successfully implement Lean production, others fail to achieve the expected results [1].

Training employees in Lean production is still one of the key strategies of organizations to implement Lean production [2]. However, most Lean training programs don't properly contribute to successful long term Lean production

implementation. For example, Bhasin's [3] research showed that a lack of adequate training is one of the main reasons why organizations fail to implement Lean production on the long term.

This paper takes a longitudinal approach and draws on the routine dynamics literature to explain why Lean training programs may not always have the expected result.

Routine dynamics literature distinguishes between enacting and patterning routines [4]. Patterning links to the shared understanding or the 'ostensive' aspect of a routine, while the enactment of a routine relates to the performative aspect [5]. In line with Knol et al. [6] this paper argues that if employees enact CI routines, it helps them to pattern and enact lean operating routines and that in turn, the enactment of lean operating routines helps them to pattern and enact in CI routines. Thus, it is the cyclical process of enacting and patterning lean operating and CI routines that help employees and thus organizations to successfully implement Lean production. However, most Lean training programs, such as our Lean QRM Yellow-belt training solely focus on the patterning aspect of routine development.

According to previous research on Lean training programs and Lean production implementation, training employees has a long-term effect on Lean production implementations [7]. Douglas, Douglas and Ochieng [7] state in their quantitative study that Lean training programs do have an effect on successful Lean production implementation, but they only focus on employees' understanding of Lean operating tools, that is patterning lean operating routines and related artefacts, to strengthen their claim. Though understanding Lean operating tools in itself is an important aspect for successful Lean production implementation, understanding CI tools and actually using these tools in CI activities is neglected as a possible explaining factor.

Thus, previous research mainly focusses on Lean training to pattern lean operating routines, whilst patterning CI routines and enacting both lean operating and CI routines are neglected. This study aims to close this gap by studying the influence of a "best-practice" Lean QRM Yellow-belt training on both enacting and patterning lean operating and CI routines and thus routine development. Therefore this paper poses the following research question:

“To which extent does our Lean QRM Yellow-belt training develop Lean Operating & Continuous Improvement Routines?”

2 Literature

2.1 Process model

Knol et al. [6] state in their research that rather than management and expert driven activities, team leader and employee enacted CI routines helped to pattern and enact their lean operating routines. In turn, if team leader and employee enacted lean operating routines helped to pattern and enact their CI routines. This cyclical process

of enacting and patterning lean operating and CI routines to successfully implement Lean production is shown in figure 1. This figure is further explained below.

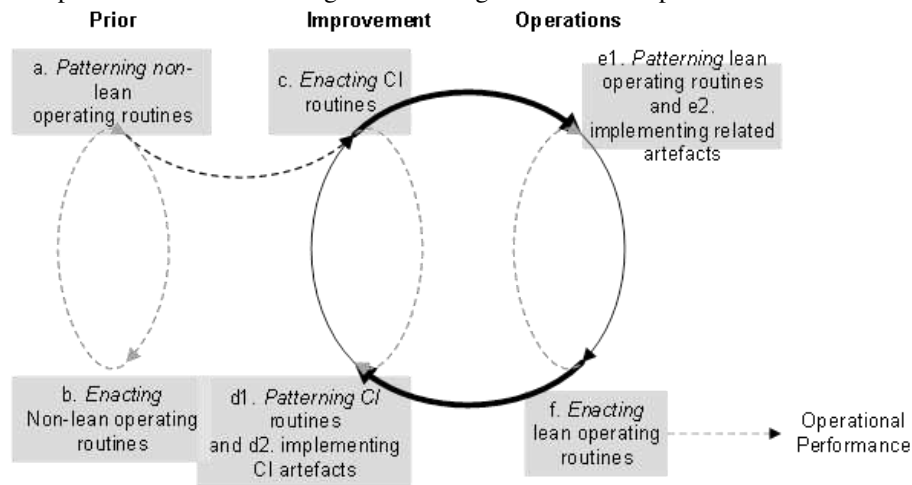


Fig. 1. The cyclical process of enactment and patterning lean operating and CI routines (Source: Knol et al. 2020)

Continuous improvement routines (a, d1 & d2 in figure 1) are, according to Knol et al. [6] aimed at continuously improving business processes, such as Ohno's Genchi Genbutsu or 'go and see the gemba' principle [8]. Rother and Shook's [9] 'Learning to see' approach, Rother's [10] Toyota Kata, CI [11], striving to continuously improve products and processes, solving problems in small groups, employee involvement, Kaizen activities, brown paper sessions, A3 & 8D-problem-solving reports, A3thinking, PDCA, 5-whys, perfection, performance boards/ performance sessions and TQM. CI routine development may or may not be visible on the basis of related physical artifacts, such as performance boards, A3 and 8D problem-solving reports, and intangible artifacts, such as Deming's [12] Plan-Do-Study-Act circle and 5-whys. Employee knowledge about these subject can be improved by: CI meetings, engaging employees in enacting CI routines, discussions to clearly explain the need, challenging employees to perform CI routines, using cycles of CI activities and templates such as 8D or A3 problem-solving reports, continuously providing employees with coaching, time and resources [8]. Enacting (c) concerns employees actually conducting improvement activities using previously mentioned concepts in daily practice, or the ability of managers to realize lasting involvement of employees in CI. Patterning (d1 & d2) concerns the extent to which employees collectively have a thorough understanding of previous concepts [6].

Lean operating routines (e1, e2 & f in figure 1) relate, according to Knol et al. [6] mostly to hard lean practices (the tools). This concerns concepts such as: value stream, flow, takt time, Little's Law, Just-in-time deliveries (JIT), supplier integration, pull, Kanban (squares or containers of signals for production control), two-binsystems, 5S (like shadow boards) and setup routines (such as doing quicker product changeovers), lines and cells. Lean operating routines may or may not be

visible on the basis of related physical artifacts, such as Kanban cards used to limit work-in-progress, 5S artifacts (such as shadow boards) and setup routines (such as doing quicker product changeovers), if also intangible artefacts, such as formulas and techniques like takt time and Little's Law (that help to determine the number of Kanban cards in the system). Opportunities to build up employee knowledge of these subjects are lean games, excursions (internal and external), training (Lean Yellow/Green/Black-belt training), involvement in improvement projects and coaching. Patterning lean operating routines (e1 & e2) concerns the extent to which employees have a thorough shared understanding of previously mentioned concepts. Enacting lean operating routines (f) concerns employees actually using previously mentioned concepts in practice [6].

2.2 Intervention - Lean QRM Yellow-belt training

In line with the distinction made by Knol et al. [6], an intervention to train team leaders and employees in Lean production best consists of the following four aspects. In addition we describe (behind the four aspects) the related parts from the given Lean QRM Yellow-belt training. The numbers in brackets indicate the order in which these parts were taught during our training.

Enacting continuous improvement routines Playing the 1st round of a lean sticklebrick game (2), playing the 2nd round of a lean stickle-brick game (jointly thinking up (and implementing) countermeasures in advance and reflecting afterwards on the improvements achieved or not) (6) and playing the 3rd & 4th round of a lean sticklebrick game (jointly devising (and implementing) countermeasures in advance and reflecting afterwards on the improvements achieved or not and the extent to which attention was paid to all Lean production principles) (11).

Patterning Lean operating routines Explaining a summary of Lean QRM and CI (with emphasis on difference between source efficiency versus flow efficiency and therefore difference between focus on costs versus focus on lead time and quality (QDC) and difference between Lean (LVHV) and QRM (HVLV) and the 5 Lean production principles (LPs) (3), explanation about customer value & waste (LP1) (4), explanation about identify the value stream (LP2) with attention to tools such as the VSM, the swimlane and the Manufacturing Critical Timepath (MCT of Suri) combined with an explanation of the Response Time Spiral of Suri (5), summary of the first day (7), explanation of flow (LP3) with attention to the effect of batches on lead time and work in progress work (Little's law), influence of changeover times (SMED), takt time, line balancing, utilization rate versus lead time and the impact of variability on lead time (8), explanation of difference between push and pull (LP4) with attention to Kanban and two-bin systems (9) and explanation about 5S, standards and visual management (10).

Enacting lean operating routines By playing the 1st round of a lean stickle-brick game (2), making a homework assignment of at least 2 photos of waste at their own workplace (LP1) (4), preparing a homework assignment MCT for a product in which

they are involved (5), playing the 2nd round of a lean stickle-brick game (jointly thinking up (and implement) countermeasures beforehand and reflect afterwards on the improvements achieved or not) (6), playing a short game regarding 5S, standards and the importance of visual management (10) and playing the 3rd & 4th round of a lean stickle-brick game (jointly devising (and implementing) countermeasures in advance and reflecting afterwards on the improvements achieved or not and the extent to which attention was paid to all lean principles) (11).

Patterning continuous improvement routines Explanation 'Why to improve?' (1), explanation about customer value & waste (LP1) (4), summary of the first day (7) and explanation about 'striving for perfection' (LP5) with attention to the importance of quality, the hidden factory, Jidoka, Andon, Mistake proofing & Poka Yoke and the KATA-model (10).

2.3 Hypotheses

In line with Knol et al. [6] we formulated the following hypotheses:

H1a: 'The Lean QRM Yellow-belt training intervention has a positive effect on the enactment of CI routines of employees at Firm x'.

H2a: 'The Lean QRM Yellow-belt training intervention has a positive effect on the development of patterning Lean operating routines of employees at Firm x'.

H2b: 'The Lean QRM Yellow-belt training intervention has a positive effect on the enactment of Lean operating routines of employees at Firm x'.

H1b: 'The Lean QRM Yellow-belt training intervention has a positive effect on patterning CI routines of employees at Firm x'.

3 Method

3.1 Research strategy

This research is based on a deductive, pre-post interventional research design, since theoretical concepts are derived from existing literature and the data regarding Lean operating- and CI routines were collected in two points in time, with the Lean QRM Yellow-belt training as intervention. Measuring differences in only two points in time is usually a poor method of longitudinal analysis, however both the information- and time difference between the first and the second measurement are fairly uniform for all subjects, making the effect of only two measurements negligible [13]. Pre-post interventional study designs have the strength of temporality to suggest that the outcome is impacted by the intervention, however, pre-post intervention designs do not have control over elements that are changing at the same time that the intervention is implemented [14].

3.2 Case description

The subject of this research concerns the Lean QRM Yellow-belt training as given to one of the partners of our HAN Lean QRM Centre in the Netherlands. This partner firm is market leader in the production of front linkage systems and manufacturer of track systems for tractors. They first got to know Lean production in 2014 and in 2016 the first 55 (out of approximately 350) employees were trained at Yellow-belt level, followed by approximately 6 employees at Green-belt level. In 2019, the firm aimed to have at least 25% of its employees trained at the Yellow-belt level to improve their knowledge level of Lean production, QRM and CI. In the fall of 2019 and spring of 2020, 88 employees (in 7 groups) were subsequently trained in a 2-day Lean QRM Yellow-belt (with a week in between).

3.3 Data quality

In order to test the hypotheses of this study, quantitative data is gathered through an exploratory questionnaire. The questionnaire is derived from existing, widely accepted literature and constructs are operationalized accordingly. Questions regarding to Lean operating routines are derived from the study of Spear and Bowen [15] on Toyota employees' behavior. Items related to CI routines are based on eight different key constructs identified by Bessant et al. [16]. Whereas Bessant et al. [16] use thirty-five items to measure the full extent of CI behavior, the seven items mostly related to understanding and enacting CI. are used in this paper. Additionally, all items were carefully translated from English to Dutch by two independent individuals who used "back and forward translation". In order to ensure the research quality, the questionnaire was also checked by experts in the field of Lean production in order to control for inconsistencies and vagueness of concepts. The suggestions and feedback in turn were used to improve the questionnaire. All data was collected on an individual level.

3.4 Data Analysis

For the purpose of the research, the questionnaires (t1 & t2) were sent to all 88 participants of the Lean QRM Yellow-belt training. In total 49 questionnaires were filled in for both t1 and t2, generating a response rate of 58%. After checking for missing values, 17 pairs were deleted listwise, leaving only 32 pairs applicable for comparison. Additionally, we checked for outliers and normal distributed data. Hence, no extreme outliers were found and the data is fairly normally distributed. However, due to constraints, boxplots are used to compare the mean scores of the pre and post-tests.

4 Results

In order to determine whether the Lean QRM Yellow-belt training program affects the development of Lean operating and CI routines, this study looks at the mean differences between the pre- and post-intervention test. Table 1 shows the descriptive statistics of both the pre- and post-test related to both patterning and enactment of

Lean operating and CI routines. According to the process model presented by Knol et al. [6], the development of routines starts with the enactment of CI routines. This studies hypothesis states that after the training program, employees of the firm would score higher on the enactment of CI routines. The descriptive statistics (table 1) however show that the mean score of enacting in CI routines after the training program slightly decreased.

Descriptive Statistics				
	Min.	Max.	Mean	Std. Deviation
(Pre) Enacting CI Routines	3.83	8.00	5.95	1.18
(Post) Enacting CI Routines	2.33	7.67	5.91	1.19
(Pre) Patterning Lean Routines	2.00	8.00	5.23	1.34
(Post) Patterning Lean routines	4.50	8.00	6.42	1.00
(Pre) Enacting Lean Routines	4.00	7.67	6.01	0.770
(Post) Enacting Lean Routines	4.33	7.67	6.22	0.874
(Pre) Patterning CI Routines	3.50	8.00	6.05	1.04
(Post) Patterning CI Routines	4.50	8.00	6.57	0.90

Table 1. Descriptive Statistics

The difference in both mean score and standard deviation is negligible, indicating that after the training, employees on average did not enact more in CI routines. The last two boxplots on the right illustrate the differences of CI enactment in the pre- and post-test. Figure 1 illustrates the differences in mean scores for the first two steps of the process model.

The descriptive statistics do show that patterning Lean operating routines is increased by 1.18 and that the standard deviation is slightly decreased by .330, implying that on average the respondents have better understanding of the Lean operating routines. The first two boxplots of Figure 3 illustrate the difference in scores for patterning Lean Operating Routines. Whereas the first boxplot shows the preliminary results of patterning Lean Operating Routines, boxplot two illustrates the results of the post-test. Additionally, the descriptive statistics indicate that on average the scores of enactment in Lean operating routines is marginally increased, but that the standard deviation also is increased (see also the last two boxplots of Figure 2). This would imply that there is no clear evidence that participants enact more in Lean operating routines after the intervention.

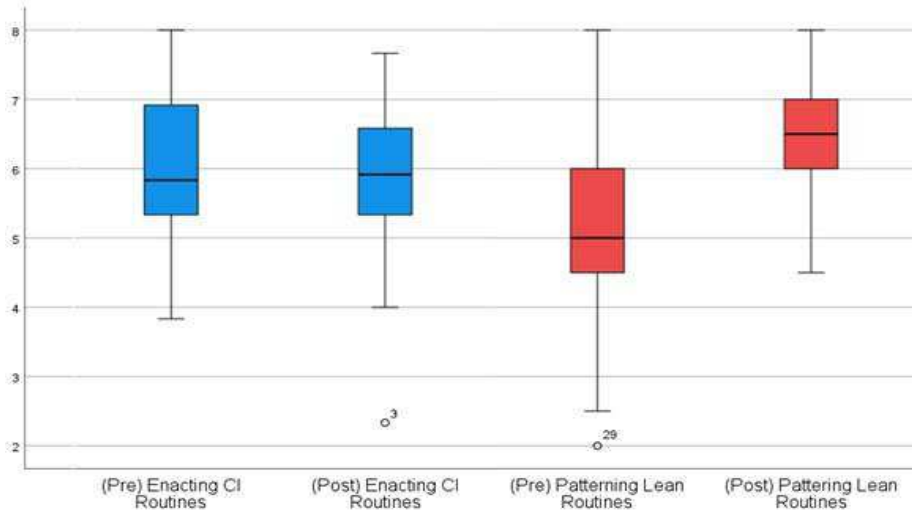


Fig. 2. Boxplots Differences in first two steps process model: Red: Lean Operating Routines, Blue: CI routines

The table above also provides information between the differences related to the patterning CI routines. The patterning of CI routines is on average increased with .467, and the standard deviation is decreased, which implies that the respondents slightly understood the CI routines better after the intervention (see also the first two boxplots of Figure 3).

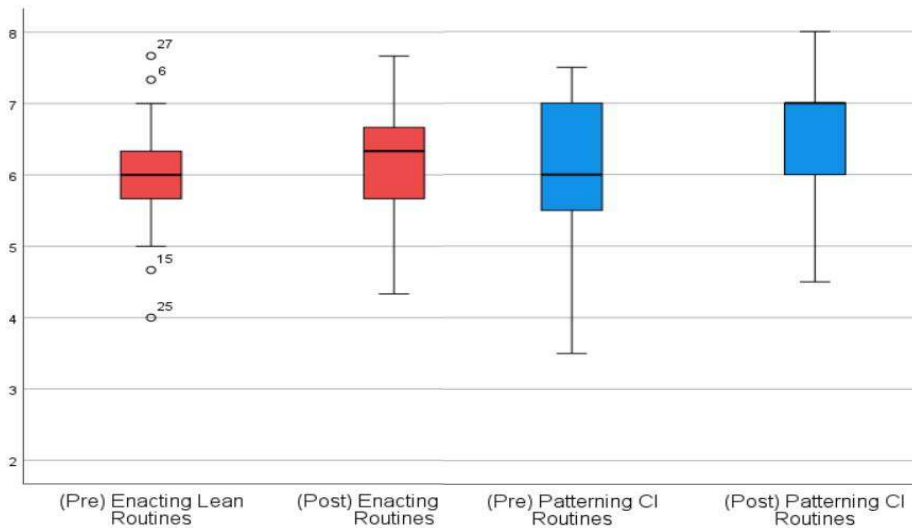


Fig. 3. Boxplot Differences in Mean scores. Red: Lean Operating Routines, Blue: CI Routines

On balance, this has led to the following overview of confirmed or rejected hypothesis (see table 2):

Construct	Hypothesis	Result
Enacting CI Routines	H1a. The Lean QRM Yellow-belt training intervention has a positive effect on the enactment of CI routines of employees at Firm x	Rejected
Patterning Lean Operating Routines	H2a. The Lean QRM Yellow-belt training intervention has a positive effect on patterning Lean operating routines of employees at Firm x	Confirmed
Enacting Lean Operating Routines	H2b. The Lean QRM Yellow-belt training intervention has a positive effect on the enactment of Lean operating routines of employees at Firm x	Rejected
Patterning CI Routines	The Lean QRM Yellow-belt training intervention has a positive effect on patterning CI routines of employees at Firm x	Confirmed

Table 2. Overview of Hypotheses

5 Conclusion

This study posed the following research question: “To which extent does our Lean QRM Yellow-belt training develop Lean Operating and CI routines?”. Since lean operating routines originate from enacting CI routines, we studied what the effects of the training were on the development of enacting and patterning Lean Operating and CI routines.

The results of this deductive pre-post interventional exploratory research on the effects of the HAN Lean QRM Yellow-belt training on Lean operating and CI routine development are clear. Whereas Knol et al. [6] imply that the cyclical development of new routines starts with the enactment of CI routines, these results show that the current Yellow-Belt training, does not influence the enactment of CI routines by employees at this firm (H1a). The understanding and thus the patterning aspect of the lean operating routines (H2a) as well as the CI routines (H1b) is increased due to the two-day HAN Lean QRM Yellow-belt training program. In contrast, the enactment of the lean operating routines (H2b), shows no significant growth. Seen from the perspective of Knol et al. [6], these results imply that the HAN Lean QRM Yellow-belt training does not make a complete contribution to sustained Lean production implementation since the training in itself is not yet enough to develop and enact new Lean operating and CI-routines. So far, the HAN Lean QRM Yellow-belt training only contributes significantly to the patterning of lean operating and CI routines.

6 Discussion

6.1 Limitations and future research

Although this study reveals interesting findings, it has several limitations. First of all, even though the questionnaire is based on recognized literature, it has not been checked for internal validity and reliability, for example by using a factor analysis, or Cronbach's Alpha. Follow-up research should therefore pay attention to the content, validity and reliability of the questionnaire and develop it further. We used a pre- and post-measurement, over a period of three months. Developing routines can take longer, so the full effect of the training may not have been mapped. Follow-up research can therefore choose to schedule three measurement moments, over a longer period of time, in order to get an even better picture of the development of the routines. The current results show that in particular the enactment of both lean operating routines and CI routines lag behind. However, it is unclear what the effects of the Covid-19 outbreak are on the outcome of this study. Further research can replicate and complement this research.

Initially, we wanted to use a dependent samples t-test, in order to demonstrate the effects of the training with more certainty. We therefore checked for the requirements associated with such a test. For example, outliers, normal distribution of the data and a required sample size were examined. This study met two requirements, there were no outliers in the data, and the data was relatively normally distributed (the ShapiroWilk test was used for this), however, we did not have enough pairs to compare. We needed 45 pairs according to the G-power test, but in the end, we had 32 similar pairs in the data. To develop a firmer picture of the effects of Yellow-belt training on routine development, further research could therefore adhere to these guidelines.

6.2 Practical Implications

The results of this research are interesting for trainers of similar training courses such as the HAN Lean QRM Yellow-belt training. Explaining many concepts does lead to understanding or patterning of lean operating and CI routines, but the interventions deployed in the field of enactment, such as playing games (2, 6, 10 & 11) and giving homework (4 & 5), in this case turned out to have insufficient effect on a sustainable implementation of Lean production. On the one hand, it is therefore necessary to consider how the deployed interventions can lead to a higher return on the offer of enactment, and on the other hand, it must be considered which additional interventions can be used to achieve the same result. Participants in a Lean QRM Yellow-belt training can already during (or afterwards) the training think about how they can implement what they have learned during the training in their own practice, or even conduct a project during the training. In addition, management should also take responsibility for perpetuating the yields of the Lean QRM Yellow-belt in daily work practice.

6.3 Reflections

For us, these results have led to two clear improvement actions. First, we will from now on pay even more attention to the enacting of CI routines during our Lean QRM Yellow-belt training, whereby we find it especially important to pay even more attention than before to the transfer of what has been learned in the course to the daily practice of the participants. Second have we developed a so-called ‘CI Workshop’, consisting of 5 afternoons (biweekly) in which the participants will work under our supervision on a joint improvement project (approximately 12 participants work on a total of 3 improvement projects) by means of the A3 problem-solving methodology. After these workshops, these participants are coached 5 more times or more by us in the further implementation of their improvement project and/or the start-up of a next improvement project. Future research will show what the effect of this will be on the enactment of lean operating and continuous operating routines. In addition, we will also extend this research to our HAN Lean QRM Green-belt training courses. Finally, in order to develop our understanding of CI- and Lean routines, it is necessary to improve the robustness of the questionnaire and amount of participants. So that we in turn can use statistical analysis to the fullest extent.

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