Sustainability of lean manufacturing principles in a production system

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Abstract

The success of manufacturing organizations at large is assessed through the ability to perform day to day business employing efficient methods and techniques of working. Lean manufacturing comprises of several essential principles for executing production in an organization. Several organizations have explored the need to implement lean principles in pursuit of improving productivity thus achieving a competitive advantage in the volatile global business space. This paper investigates the factors which affect the sustainability of lean manufacturing principles in a production system. To obtain an insight on the factors affecting the sustainability of lean manufacturing, a literature study on lean holistically and the principle is explored. The purpose of the literature is to learn proposals made in literature in relation to sustaining the practice of lean principles. The remediation suggested in literature is used to explore possible best practices that can be embedded in the daily business of an organization to promote lean principles sustainability. The literature in this study brings into attention significant themes essential to arrive to significant outcomes. The themes of study range from organizational leadership and culture followed by the organization to promote the best application of the principles. To gather research data, observations are used as the main data collection method. A checklist is used to provide a structure on the observations under the different themes. Without overlooking the other themes of the research, the research reports that of all the observed themes with different observable items the main themes which need attention are shop-floor meetings, training and problem solving. The analysis of the entire research reveals that if the manner with which training is conducted improves could alleviate many other problems as training proves to be the main contributor towards other factors.

Keywords
Lean manufacturing, Principles, Sustainability, Production system.

1. Contextual Background

Lean is a set of tools and techniques employed and sustained by various companies with the aim of achieving increased production and the entire customer value chain without overlooking elimination of waste (Mwacharo, 2013). Organizations are often faced with the challenge of operating in a dynamic and competitive environment. It is for this reason why organizations have to seek improved approaches to enhance efficiency and remain relevant in the competitive space. Lean manufacturing is suggested to be a useful tool for improving efficiency in an organization (Mapfaira, et al., 2016). It aims at simplifying and organizing the workplace therefore, promoting elimination and reduction of waste from the processes throughout the organization (Mapfaira, et al., 2016). An efficient production system is usually characterised by flexible delivery times, standardised methods of carrying out duties, defect free processes, robust processes with less waste to mention a few aspects. What appears to be a positive approach towards realising this goal is through the practise of lean principles and techniques (Blažić, et al., 2017). A significant amount of literature mostly focuses research on the benefits of implementing lean manufacturing principles in an organisation however, researchers have acknowledge the amount of effort needed towards the implementation of a successful lean manufacturing program and reveal that limited research has been devoted towards difficulties experienced to sustain lean manufacturing once implemented in a production system. The sustainability of lean is a subject worth looking into with regards to the manner of maintaining the energy and interest of the established pilots, execution of improvement ideas and unleashing the ability of teams in the organisation to implement lean (Jørgensen, et al., 2007).

This research focuses on identifying the factors which impact the sustainability of lean manufacturing principles in a manufacturing organisation. Literature review stipulates the importance of lean leadership and culture transformation to sustain lean initiatives (Mann, 2010). In purpose of identifying influential factors towards lean manufacturing principles sustainability, the research pays attention to specific themes in literature. These themes are used as the fundamental part of the research through observing aspects of interest advocated in literature. In light of conducting the research, the selected themes of interest were used to extract particular best practices essential for organisations to sustain the application of lean principles in the daily business. The main themes of literature used to manipulate the best practices are shop-floor meeting, training, value streams, problem solving and shop-floor coaching.

1.1 Lean Sustainability

Sustainability is defined as the ability to meet today's needs without jeopardizing the ability to meet the needs of the future generations (Resta, et al., 2014). In the context of this research sustainability refers to the ability to maintain the reliability of production processes in a company through the implementation of lean manufacturing which equips the individuals of the organization with useful tools and techniques necessary to sustain the processes. The companies which embrace lean manufacturing have been able to improve their competitive advantage (Martìnez-Jurado and Moyano-Fuentes, 2014). The sustainability of any organization is to have a substantial advantage over its competition, taking into consideration the rise on technological advances and established markets around the globe (Jadhav, et al., 2014); Reis, et al., 2016; Kumar and Abuthakeera, 2012). Lean manufacturing is simply centered on a transformed way of thinking and performing daily work therefore, requires a strong cultural change essential for sustaining the lean principles and beliefs (Alves and Alves, 2015). Organizations miss the chances of establishing a sustainable lean system due to much focus given on lean tools and physical changes when implementing lean instead of focus on lean culture (Mann, 2010; Sidinile, 2014).

1.2 Lean Culture

Organizational culture is a set of inferences and beliefs which the organization has developed over the years of dealing with problems its challenges (Schein, 1984) cited in (Lotz, 2013). Leadership is the main driver behind developing and transforming a culture (Schein, 2010) cited in (Smith, 2016). The majority of lean adopters employ certain improvements and tools prescribed by the quality specialist to deal with projects and this follows a top-down approach (Zarbo, 2012). This approach overlooks the essential practices pertaining to Toyota's positive lean results in the form of a workplace culture driven by knowledgeable employees, with well-defined structures which facilitate consistent practice of desired behaviors and incentive schemes to promote engagement amongst the employees at all levels (Zarbo, 2012). A successful lean culture of continuous improvement is attained when employees are able to sustainably perform their daily duties and achieve impressive quality targets in the absence of the team leader (Zarbo, 2012). A healthy culture is achieved when the beliefs, the way people think and act is uniform throughout the organization. This type of behavior is an integral part of Toyota's culture which has resulted in the development of unique principles such as "Kanban" and "Autonomation" (Wilson, 2010). For instance Toyota's culture from the shop-floor workers perspective reveals the culture of best work practices which suggests that when a defect has occurred the entire production line should be shut down and only when the source of the defect has been found will the line be operated again. This principle is referred to as Jidoka, it is the responsibility and right of the worker to apply it when necessary (Wilson, 2010). This culture of encouraging employees to take accountability of the problems in their processes and improving continuously is attributed to different attitudes and behaviors (Lotz, 2013). Essentially, culture has significant dimensions in the form of noticeable behaviors or manner with which people do things however, it has not escaped to mention that it is rather important for an organization to comprehend culture at a theoretical perspective prior to translating it in a practical level namely kaizen culture (Miller, et al., 2014

1.3 Kaizen Culture

Kaizen simply refers to changing for good, better known as continuous improvement (Miller, et al., 2014).Continuous improvement suggests finding better methods of executing production (Rathilall, 2011). Continuous Improvement is a management concept that should be used in purpose of driving cultural shift in the workplace (Sundara, et al., 2014). The culture of maintaining improvements should be the main basis of continuous improvement (Bhuiyan & Baghel, 2005) cited in (Rathilall, 2011). This culture of maintaining improvements comes in the form of small incremental improvement and the involvement of everyone in the organization (Ohno, et al., 2009) referenced in (AdedejiI, 2011). Kaizen remains the most influential approach in lean manufacturing (Glover, et al., 2015). In a case whereby escalation of problems doesn't prove to be sufficient, the kaizen approach facilitates a platform in the form of kaizen events whereby all the relevant people regarding the problem are brought together. The main goal of kaizen events is to determine problems, brainstorm possible solutions and deploy resources accordingly (Martin, 2014). The participation

of production employees and leaders in continuously improving the processes and products is essential for continuous improvement (Rathilall, 2011).

1.4 Lean Leadership

Lean leadership is not appropriate for lean production system or neither just a supplementary concept. In true sense it is essential for establishing a continuous improvement of the lean production system and all its operations (Dombrowski and Mielke, 2013). It is the apparent gap between lean tools, the actual application and the continuous improvement of the orgisations (Orr, 2005; Mann, 2009) cited in (Dombrowski and Mielke, 2013). Lean leadership is the systematic approach for establishing sustainable implementation and continuous improvement. This approach delineates the coordination of employees and leaders towards achieving the same goal being, perfection (Dombrowski and Mielke, 2013). A lean leader should be an individual with the interest to develop the leadership skills essential to positively influence the workers to the extent to which they are able to improve and manage with challenges and targets at all levels therefore, contributing towards continuous improvement and long term objectives in the organization. On the same note, Liker (2006) explains that it is easy to spike the interest of leaders towards recognizing the benefits of lean in the organization but what usually leads to failed efforts is the inability of the executive members to take action and give full support (Liker and Meier, 2006). Research reveals that in pursuit of capacitating the leaders in the organisation Toyota developed a lean leadership model. This model presents four stages a leader must undergo during development, to achieve the required mind-set shift necessary to lead people.

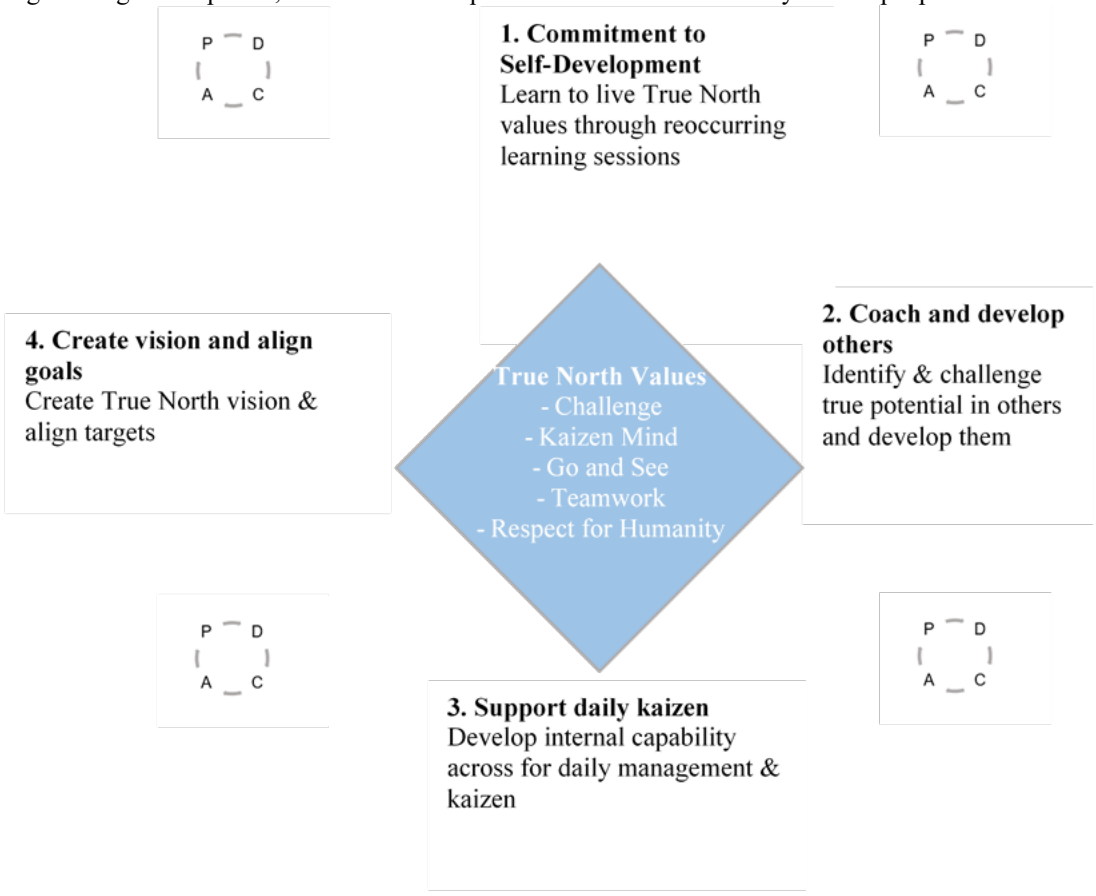

Figure 1. Diamond model for lean leadership (Dombrowski & Mielke, 2014).

1.5 Coaching

Leaders are aware of the strengths and weaknesses of the people however, learn to attain and focus on the positive results through limited involvement. The aim of coaching is to stimulate the employees' capabilities by encouraging them to take control of any situation thus achieving desirable results (Trenkner, 2016). It is the mandate of the leaders to transfer the cultural beliefs and values of an organization, they should encourage and stimulate the culture of learning and sharing knowledge (Mann, 2005) referenced in (Poksinska, et al, 2013). The engagement between

operators and leaders forms a foundation for continuous improvement at shop-floor level and has been overlooked in western lean manufacturing approaches (Ehni and Kersten, 2015). In purpose of filling the gap between the operators and leaders, a study conducted by Liker and Franz reveals that Toyota developed a structure of improvement processes which could be integrated into the daily routine on shop-floor (Ehni and Kersten, 2015). Toyota has adapted this approach on shop-floor and practiced under the supervision of a coach. This method is known as Toyota kata. This method is motivated by the martial arts procedure where by motion is repeated continuously until it becomes second nature (Ehni and Kersten, 2015). Toyota kata comprises of two type of katas namely improvement kata and coaching kata. Improvement kata is used to develop daily improvement and coaching kata coaches on these daily improvement with the help of a coach or leader. An improvement kata card can be used to facilitate the improvement and learning process. The first three questions on the card focus on the target conditions and are known as framing questions (Soltero, 2012).

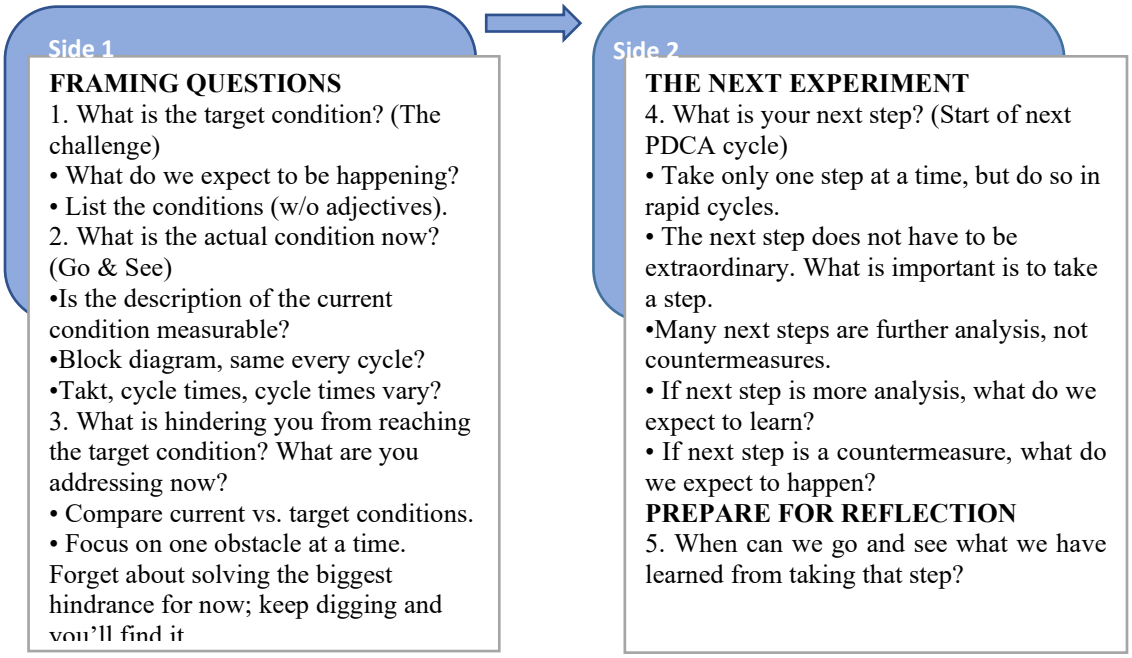

Figure 2. Improvement kata card adapted from (Soltero, 2012).

1.6 Qualification

This is an elementary task in lean leadership. It equips employees with the necessary skills for taking part in continuous improvement. The continuous improvement of processes must complement the continuous development of subordinates. Qualification is not strictly confined to classroom training but rather should take place on shop-floor on a daily basis. Conveniently coaching is the best approach to challenge the employees to come up with solutions for the actual problem (Liker and Convis, 2011). Research reveals that there is close to little written about Toyota Production System in the form of books or operating manuals however, brochures and handouts are the only form of script available. This is because Toyota advocates the importance of a spoken word to transfer knowledge from one generation to the next (Piatkowski, 2004). Toyota has in house consultants which help the senior managers improve the major departments but each leader has the responsibility to training its employees nearly every day. All the newly appointed leaders and managers are expected to spend a day working on the line. If there is a new employee or promoted manager, the expectation is to have an experienced mentor side by side to teach the individual on TPS. This approach has proved to be authentic as everyone gets the same message and teaching with regards to the Toyota Production System philosophy (Piatkowski, 2004).

1.7 Gemba

Genchi gembutsu namely Gemba is one of the main tools in lean. This tool is by means of encouraging managers to go and see the clear state of what is happening in purpose of getting a better understanding (Thorhallsdottir, 2016). There are notable methods of partaking in Gemba however, those who actually take part in Gemba walks should be mindful at all times by seeking the essential information such as asking why, observing and offereing the necessary

support (Liker, 2004) referenced in (Thorhallsdottir, 2016). The idea behind the Gemba should be to observe how work is performed, pose open-ended questions, be open minded and coach the workers on the simpler methods of performing the work. The application of the Gemba principle takes into consideration the Ohno circle in the form of an imaginary or real circle. The leader steps into the circle with the aim of observing the process with failures (Dombrowski and Mielke, 2013). The observation of the process could possibly take several hours until the process with failures is understood therefore, the decision on possible improvements will be influenced by apparent facts. The logic behind the Ohno circle suggests that leaders should go on the shop-floor and get their hands dirty to improve the process. This concept also suggests that the leaders should have their offices located close to shop-floor in appreciation of the shop-floor operations in the organization. Dombrowski and Mielke (2014) explain that Gemba is the time which leaders can use to practically develop their employees through their daily work routine on the shop-floor instead of using artificial examples for training (Dombrowski and Mielke, 2014).

1.8 Problem solving

Allowing individuals to tackle real problems with no currently existing solutions could be an effective way of building the required competency. Finding ways to address the problem and reaching a sustainable solution to the problem contributes towards the development of the necessary competencies. Nowadays, experience is the normal approach of finding a solution to a problem as well as relying on executives who assume the role of experts instead of working on structured problem solving (Christiana, et al., 2015). The considerable amount of knowledge essential for solving problems is found amongst the line workers not the engineers therefore, in this way the line workers become knowledge workers however, training and learning are necessary to enhance the skill (Arbós and Nadal, 2006). The involvement of the workers working with the process is a basic principle in problem solving methodology (Wojtaszak, 2015). The problem solving process, problem complexity is an important factor to be looked into. The complexity is categorized into simple problems which can be solved by the operator, semi-complex problems which can be solved by team leader including the team as well as support functions and complex problem which need the attention of the managers (Christiana, et al., 2015). In attempt of resolving the problem, the resolution process requires a team approach and should start at the bottom of the hierarchy, the operator level to the level of engineers however, simple problems can be entrusted in the hands of the operator (Wojtaszak, 2015).
Work done by Taiichi Ohno revealed that the reality of problem solving lies in the ability of finding the root cause to the problem than identifying the source (Liker J. K., 2004). The five why analysis compels individuals to search deep about the root cause of the problem without having to settle for temporary solutions to the problem (Wojtaszak, 2015). The problem solving process in Toyota is presented in the form of an A3 report which follows the PDCA cycle to track progress.

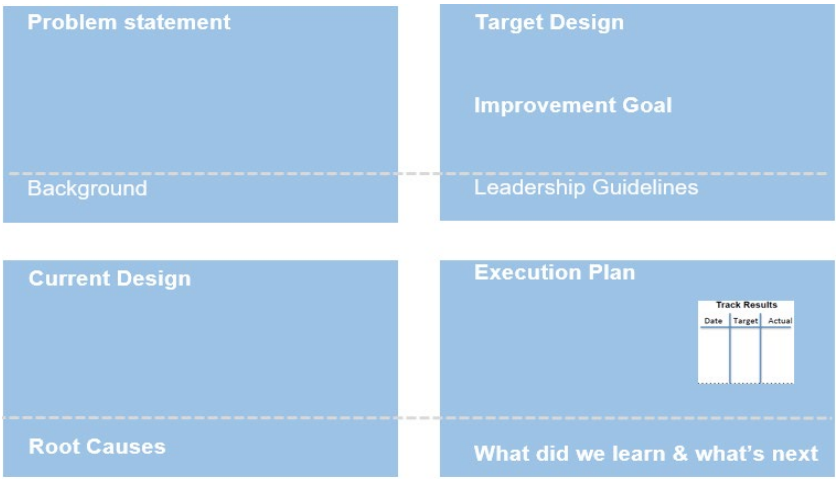

Figure 3. A3 report problem solving format adapted from (Astor, et al., 2016).

1.9 Value streams

This principles aims at studying each step of a production process from beginning to end in purpose of eliminating any form of waste. Ideally, the analysis of each process step, waste identification and elimination should improve the efficiency of the entire value chain therefore, achieving short lead times between order placement and order delivery

(Borris, 2012). The value stream mapping requires five core steps executed by the special team being; identifying the product family, mapping the current state, mapping the future state, defining a work plan and executing the work plan (Cottyn, 2014). The value stream exercise requires a careful selection of the team and that usual mistake is selecting irrelevant candidates for the exercise (Erikshammar, et al., 2014). Research indicates the need of having an individual, a value stream manager that will mainly run with the responsibility of understanding a specific product family for the value stream and realising the identified improvements (Rother and Shook, 1999). The analysis of the current state map requires certain data in the form of cycle time at each process, change over time, uptime and number of operators available during analysis. After the analysis of the current state, a future plan and lean transformation plan is developed (Cottyn, 2014).

2. Methodology

The objective of this study is to identify the factors that affect the practice of lean manufacturing principles in a manufacturing environment and to examine the application of the principles within the organization under study as suggested in literature. The study is based on a single case study. The research team selected 24 participants to take part in the research. The inclusion criteria from each department is a combination of managers, production engineers, team leaders and process supporters. The team is selected based on their current involvement on the activities happening on shop-floor on a daily basis (Sargeant, 2012). The study is initiated by conducting shop-floor observations on selected elements. The selected elements are on the basis of shop-floor meetings, training, value streams, problem solving and shop-floor coaching. The elements are selected with the purpose of observing the application of specific aspects as recommended in literature. The observations take place over a period of 8 weeks. An observation checklist is used to break down each selected element of observation into specific observable aspects. This checklist is used to confirm the application of each observable aspect in the different departments (Prowell and Steels, 1996). To indicate application of each observable aspect under each selected element a “yes” or “no” response used.

Table 1. Research themes for observation.

Theme	Coding	Total number of questions
Shop-floor meetings	A1-A10	10
Training	B1-B10	10
Value streams	C1-C13	13
Problem solving	D1-D11	11
Shop-floor coaching	E1-E10	10

In order to investigate the factors influencing the lack of sustainability of lean manufacturing principles in a manufacturing organization, each of observable theme is broken down into observable items as indicated in Figure 5.

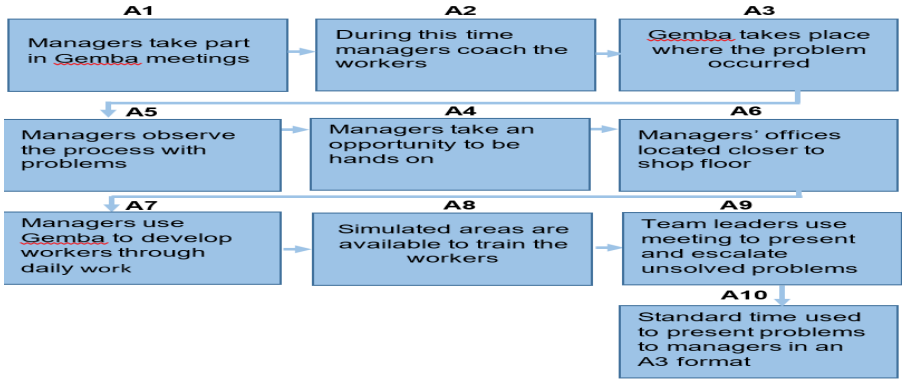

Figure 4. Observable items included in the research under shop-floor meetings.

3. Results

The observation results of each observed item under the shop-floor meetings theme indicate that only 43% of the observable items prove to be positive. This means that there is an opportunity for the organisation to improve the standard of the meetings held on shop-floor. The observation results of each observed item under the training theme indicate that only 38% of the observable items prove to be positive. This percentage could be an indication that the organisation needs to scrutinise the quality training provided to employees in order to improve lean knowledge. The

observation results of each observed item under the value streams theme indicate that only 52% of the observable items prove to be positive. The observation results of each observed item under the problem solving theme indicate that only 45% of the observable items prove to be positive. The observation results of each observed item under shop-floor coaching theme indicate that only 53% of the observable items prove to be positive.

Figure 5 portrays the quality of shop-floor meetings in the different departments as suggested in literature. The quality of the meetings is subject to the extent to which the observable items are evidenced during the meetings. The observations delineate that 92 % of the time the quality of shop-floor meetings taking place in logistics do not reflect what is suggested in literature however, in other respects 1 % of the time the meetings follow a good structure. In assembly 32 % of the time the quality of meetings shows negative practices while 72 % of the time shows positive practices. In paint shop 62 % of the time the quality of meetings shows negative practices while 42 % of the time it shows positive practices. In body shop 52 % of the time the quality of meetings shows negative practices while 52 % of the time shows positive practices.

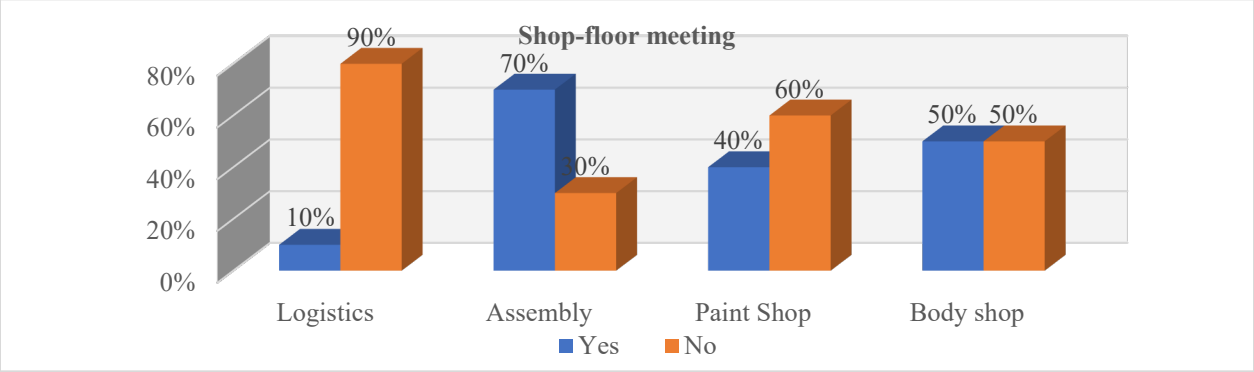

Figure 5. Contribution per technology on shop-floor meetings.

Figure 6 portrays the quality training in the different departments as suggested in literature. The quality of training is subject to the extent to which the observable items are evidenced by the research team during the training sessions. The observations delineate that 62 % of the time the quality of training taking place in logistics does not reflect what is suggested in literature however, in other respects 42 % of the time the training focuses on providing essential knowledge. In assembly 52 % of the time the quality of training shows negative practices while 52 % of the time shows positive practices. In paint shop 72 % of the time the quality of training shows negative practices while 32 % of the time it shows positive practices. In body shop 72 % of the time the quality of training shows negative practices while 32 % of the time it focuses on providing essential knowledge.

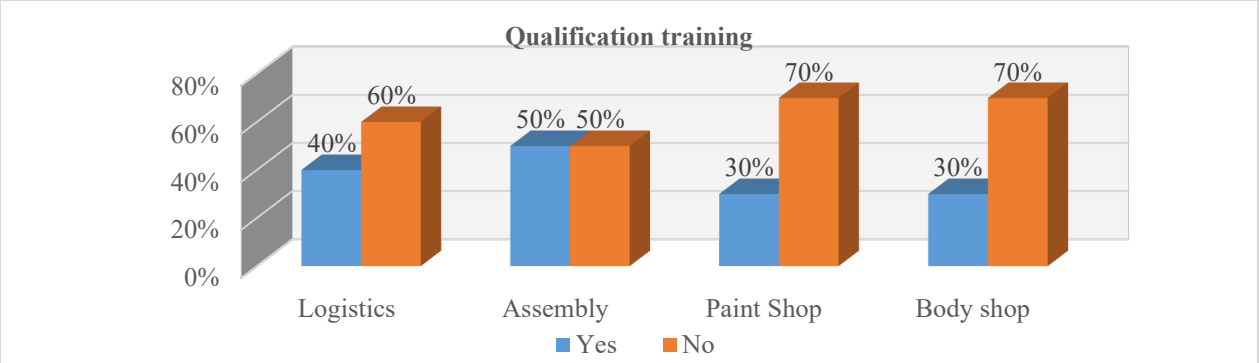

Figure 6. Contribution per technology on qualification training.

Figure 7 portrays the quality of values streams in the different departments as suggested in literature. The quality of values streams is subject to the extent to which the observable items are evidenced by the research team during mapping. The observations delineate that 62 % of the time the quality of values streams mapped in logistics do not

reflect what is suggested in literature however, in other respects 38 % of the time the quality of the values streams reveals the strength of the logistics processes. In assembly 38 % of the time the quality of values streams shows negative practices with regards to the processes while 62 % of the time shows positive practices. In paint shop 46 % of the time the quality of values streams shows improvement opportunity on the processes while 54 % of the time it shows positive practices. In body shop 46 % of the time the quality of values streams shows negative practices while 54 % of the time shows positive practices.

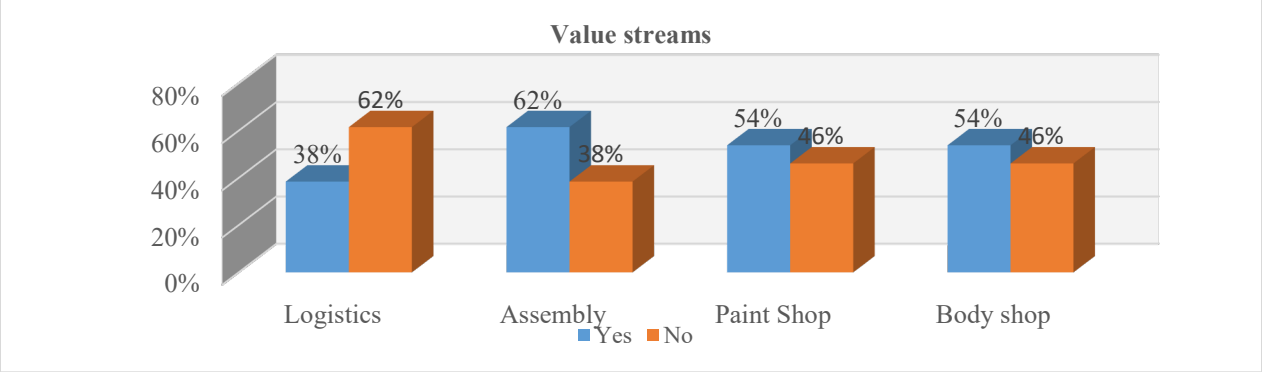

Figure 7. Contribution per technology on value streams.

Figure 8 portrays the contribution of each department towards problem solving in the entire organisation. The quality of problem solving is subject to the extent to which the observable items are evidenced during problem solving sessions. The observations delineate that 82 % of the time the quality of problem solving sessions taking place in logistics do not reflect what is suggested in literature however, in other respects only18 % of the time the quality of problem solving indicates good problem solving practices. In assembly 45 % of the time the quality of problem solving shows negative practices while 55 % of the time shows positive practices. In paint shop 45 % of the time problem solving shows negative practices while 55 % of the time it shows positive practices. In body shop 45 % of the time the manner with which problem solving is conducted reveals weaknesses in the problem solving process while 55 % of the time shows positive practices.

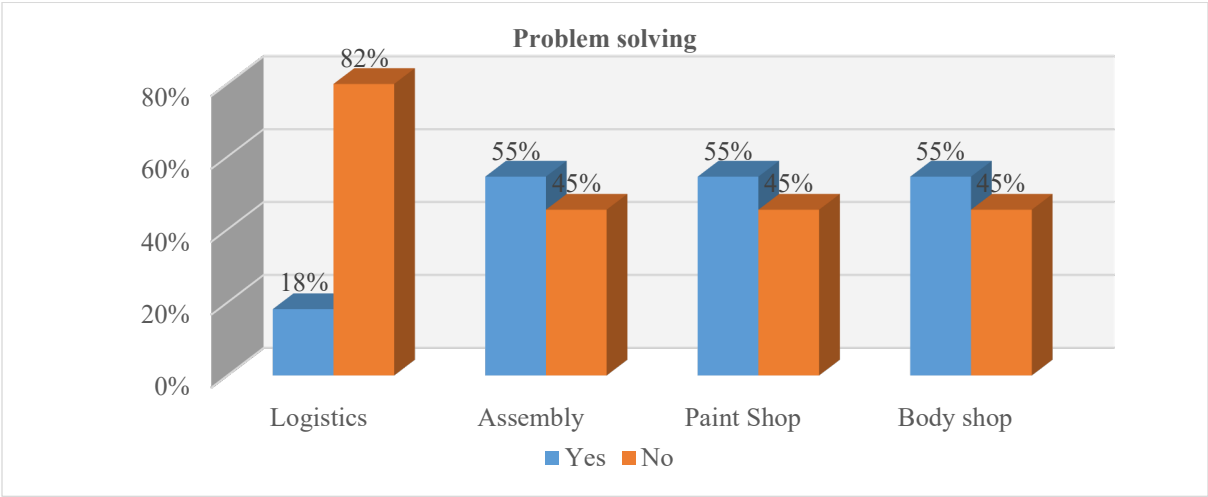

Figure 8. Contribution per technology on problem solving.

Figure 9 portrays the contribution of each department towards coaching in the entire organisation. The quality of shop-floor coaching is subject to the extent to which the observable items is evidenced during Gemba meetings. The observations delineate that 71 % of the time the quality of shop-floor coaching taking place in logistics does not reflect what is suggested in literature however, in other respects 29 % of the time the quality of the shop-floor coaching is effective. In assembly 14 % of the time the quality of coaching shows lack in the application while 86 % of the time

shows positive practices. In paint shop 14 % of the time the quality of shop-floor coaching shows a flawd approach in coaching while 86 % of the time it shows the best application of the coaching language. In body shop 71 % of the time the quality of shop-floor coaching shows lack in the application of the method while 29 % of the time shows positive practices.

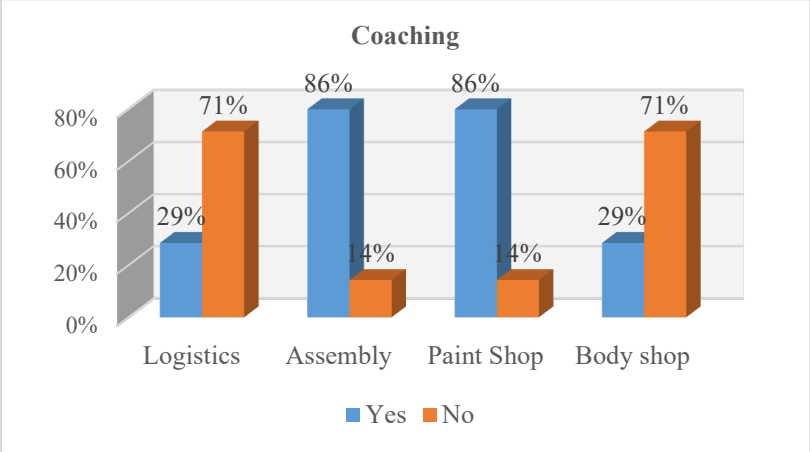

Figure 9. Contribution per technology on coaching.

Conclusion

The research team persuaded the research in purpose of studying contributors hindering sustainability of lean manufacturing principles in a manufacturing environment. The research reveals that the major contributors pertaining to failure of manufacturing organisations to sustain the application of lean manufacturing principles in an organisation. The identified gap ranges from the manner with which the organisation conducts the qualification process; and knowledge transfer to the workers to the manner with which shop-floor engagement between leaders and workers takes place. Directing focus to the respective departments, the research reveals that the logistics department is lacking on several aspects however, assembly department is currently in the lead. In light of closing the gap in lack of sustainability of lean manufacturing principles in manufacturing organisations, future research could focus on incentive schemes to promote the engagement of employees in lean initiatives. Research reveals that the majority of lean adopters employ certain improvements and tools prescribed by the quality specialist to deal with projects, however this follows a top-down approach. He suggests that this approach overlooks the essential factors pertaining to Toyota's positive lean results in the form of a workplace culture driven by knowledgeable employees, with well-defined structures which facilitate consistent practice of desired behaviours and incentive schemes to promote engagement amongst the employees at all levels (Zarbo, 2012).

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Citations:

to this paper should be made as follows: Qawekazi, S. and Telukdarie, A. (2019) 'Sustainability of lean manufacturing principles in a production system, Proceedings of the international conference on Industrial Engineering and Operations Management, Vol. …., No. …., pp ….Toronto, Canada, October 23-25, 2019.

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