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Assessing the Levels of Awareness and Implementation Effectiveness of Lean Tools in Furniture Industry: A Case Study Approach

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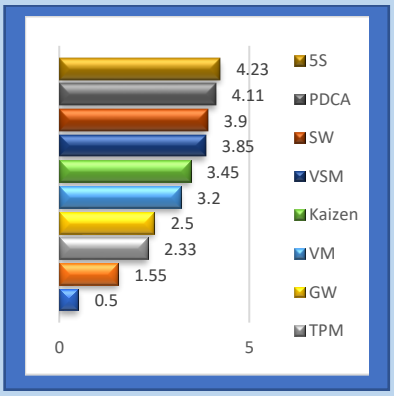
Abstract: The furniture industry faces constant pressure to improve efficiency, reduce costs and maintain product quality. To this end, the furniture industry employs diverse tools in their operations including Lean tools which emphasize waste reduction, process optimization and continuous improvement. This study aims at assessing the levels of awareness, implementation, effectiveness and the future use of Lean tools in Palestinian furniture industry as perceived by its employees. More specifically, a case study of a Palestinian furniture company of 120 employees was selected. A quantitative research method was adopted where the perceptions on Lean tools were collected from a random sample of employees using a self-administered questionnaire. It was found from the analysis that awareness and the future use of Lean tools are of moderate levels, while implementation and effectiveness are, respectively of low and high levels. A real case in the cabinet assembly department of the company was conducted where the states of the department before and after Lean implementation were analyzed. Then, 5S, Just-in-Time and Continuous Flow tools were applied in the department. A set of performance metrics have been measured before and after implementation. The analysis revealed substantial improvements in waste reduction, cost, labor utilization, assembly time and productivity.



Keywords: Lean tools, furniture industry, effectiveness, performance measurements.

Introduction

In the midst of intense competition among companies and the rapid advancement in technology and economic landscape, simply providing a satisfactory service or product is not enough to gain a competitive advantage. Companies in both manufacturing and service industries are actively looking for different ways to attract customers. Lean principles play a pivotal role in the manufacturing industry around the globe, serving a cornerstone for efficiency, quality and sustainability. Embracing lean methodologies is essential for companies striving to optimize their processes, reduce waste and meet the ever-ending demand of today's competitive global market. By fostering a culture of continuous improvement and waste reduction, lean not only enhances productivity but also ensures the long-term success and resilience of manufacturing enterprises (1). Within the context of developing countries, lean thinking can be a transformative force helping industries overcome economic challenges, enhance competitiveness and achieve sustainable organizational performance. More specifically, by embracing lean principles and applying lean tools, industries in developing countries can unlock their full potential, improve well-being of their people and position themselves for a prosperous future in the global market place(2). Among these industries is the furniture industry which not only shapes the aesthetics of our homes and workplaces but also influences our comfort, functionality and general health. It also plays an important economic, environmental and social role and contributes to job creation, innovation and sustainability. However, this industry is well-known by the significant amounts of wastes generated during manufacturing, distribution and disposal of furniture products. Such wastes are needed to be eliminated and/or reduced to minimize their negative environmental, economic and social impacts (3). One of the tools used for this purpose is Lean. To this end, this study aims at implementing some specific lean tools in one of the local furniture companies working in West Bank in Palestine. It is imperative that this study explores the challenges faced by the company while implementing Lean and assesses its current practices through a case study. This evaluation generally aims to enhance the performance of this company, which ultimately helps it achieve a competitive advantage. More specifically, the study aims at identifying ways to reduce the different types of wastes in the company, while conducting an evaluation of the company's performance after implementing Lean practices. By delving into these areas, this research seeks to highlight the effectiveness of Lean in the furniture industry and its ability to drive improvements in operational efficiency and waste reduction. In this study, we seek to address several research questions that were central to achieving our goals. Firstly, we aim to identify the level of awareness, implementation, effectiveness and future use of Lean tools used by the company and assess

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their effectiveness in reducing wastes. Secondly, we seek to evaluate the results after applying these Lean tools and to determine their adequacy and level of satisfaction. Additionally, we validate The company's need for additional tools and the importance of providing its teams with more opportunities to execute. By delving into these inquiries, we aim to gain comprehensive insights that would contribute to the success of our study.

The rest of the paper is organized as follows. Section two presents the literature review pertinent to Lean principles, tools and previous studies. Section three presents the study objectives and questions. The research methodology is given in section four. Section five presents the data analysis and results. Section six discusses the results. Section seven includes the theoretical and practical implications. Section eight concludes our work and presents the limitations of the study.

Literature Review

Lean and Wastes

During the 1920s, Henry Ford was creating something that was known as flow production system that integrated the production system into a process sequence. This was a breakthrough in manufacturing production. Later on, lean principle developed by automobile company called "Toyota" under the supervision of Taiichi Ohno to create Toyota Production System "TPS"; focusing on determining the value of the process, and distinguishing between added value activities and non-value-added activities and eliminating different types of waste (4). Lean Enterprise Institute (2000) defines that the main idea of Lean is to deliver more value for customers with minimum resources. In the same lines, (5) define Lean as an approach for identifying and eliminating wastes and improving flow of a process while engaging employees. Before any process improvement is initiated, the value of the process should be determined. Value is defined by identifying how the product or service and the cost linked with the product or service in order to meet the customer's need. Murmura and others in (6) state that: "there are five principles to Lean thinking: defining the value, identifying the value stream, removing interruptions to the value flow, letting the customer pull the value from the manufacturer, and the pursuit of perfection". These principles serve as a method to make sure that the customer receives a quality product or service. Each activity related to the product manufacturing process is inspected, whether or not it adds value and usefulness to the process. If the process is classified as non-adding value, the process would be considered waste.

The use of Lean practices, previously limited to high-volume manufacturing settings, has undergone a transformation and is now increasingly prevalent in low-volume, high-variety businesses and custom production. These settings, usually associated with workshop production systems, often entail make-to-order or engineer-to-order processes (7). However, many of these settings actually show a dominant flow in their production processes, aiming to achieve efficient and streamlined production. In addition, applying Lean principles makes it easier to accelerate manufacturing flow, create a one-way workflow, and reduce setup requirements and contract sizes(3). Thus, a large number of manufacturing processes are better represented as flow stores rather than functional stores. This transformation highlights the broad scope and adaptability of Lean applications in diverse business environments. Lean Manufacturing offers a straightforward, practical, reliable, cost-effective, pioneering, collaborative and holistic approach to reducing and eliminating waste in the wood industry. Waste, as defined by Lean Manufacturing, includes any item that adds unnecessary costs to a product without providing a corresponding value (8). In Japanese, waste is known by muda and it includes eight types of wastes abbreviated by the expression TIMWOODS, which, respectively, stands for transportation, inventory, motion, over-processing, over-production, defects and underutilized skills. Figure 1 depicts a summary of different types of TIWMWOODS.

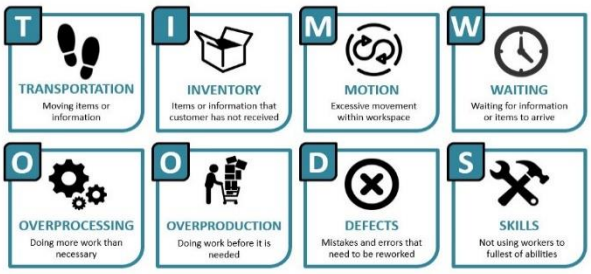

Figure (1): TIMWOODS (https://opexlearning.com/resources/28695-2/28695/)

By adopting Lean principles, the wood industry can improve product flow through the production process, reduce manufacturing lead time, foster a culture of continuous improvement, and ultimately reduce product defects. This overarching philosophy provides significant benefits and enables the timber industry to improve efficiency and drive overall excellence in its operations (9). Among the various materials used in the production of furniture, wood stands out as the most widely-used, recyclable and usable resource. Notably, wood sets itself apart from many other recyclable materials due to its renewable nature. In the field of industrial waste management systems, the primary objective is to reduce waste generation. Given the large waste sources in the wooden furniture industry, it is recommended that management strategies within the sector include quality control measures regarding raw materials and suppliers. In addition, diversification of production line and investments in manpower training and technical modernization is essential. By implementing these strategies, the wood industry can enhance waste management practices, improve material use, and contribute to a more sustainable and efficient production process (10).

Popular Lean Tools in Industry

Lean tools include a set of techniques and methodologies used in various industries, including furniture and wooden industry. Such tools are employed to improve efficiency, eliminate TIMWOODS and boost the overall productivity. These tools are the core of the Lean thinking philosophy, which focuses on maximizing value and minimizing waste. Below is a summary of some common Lean tools in industry (11):

5S: the 5S methodology (sort, set in order, shine, standardize, sustain) aims to create and organized and efficient workplace by systematically sorting, organizing, cleaning scandalizing and sustaining improvements in the workplace.

Value Stream Mapping (VSM): VMS is a visual tool used to analyze, document and improve the flow of materials and information within a process. It helps identify bottlenecks and areas for improvement.

Kaizen: It is a continuous improvement approach that encourages small and incremental (gradual) changes in the

processes and involves all employees in the improvement process. It fosters a culture of continuous improvement.

Just-In-Time (JIT): JIT is a production strategy that aims to produce items as needed, reducing excess inventory and minimizing storage costs. It helps reduce waste associated with overproduction and excess inventory.

Kanban System: It is a visual scheduling system that uses cards or signals to trigger production or replenishment of materials based on actual demand. It helps maintain efficient inventory levels and production flow.

Poka-Yoke: Poka-Yoke or mistake-proofing involves designing processes or tools in a way that prevents errors or defects from occurring. This helps reduce defects and improve product quality.

Single-Minute Exchange of Die (SMED): SMED is a set of techniques for reducing the time it takes to change over a machine or process from one product to another. This minimizes downtime and increases production flexibility.

PDCA: It stands for Plan-Do-Check-Act and it is a popular and widely-used management framework for continuous improvement and problem solving. Developed by Dr. W. Edwards Deming, PDCA is also known as the Deming Cycle. It provides a systematic and iterative approach to improving processes, products and services in a wide range of industries.

Total Productive Maintenance (TPM): TPM focuses on equipment reliability and maintenance to ensure machines are always ready for production. It reduces downtime and maintenance-related waste.

Andon: Andon systems provide real-time visibility into the production process, allowing workers to signal issues or stop production when a problem arises, facilitating quick problem-solving.

Continuous Flow (CF): This lean tool aims to create a continuous and smooth production process, reducing batch sizes and waiting times. It is often associated with assembly lines or cellular manufacturing.

Root-Cause Analysis (RCA): Techniques like the 5 Whys and cause-and-effect (Ishikawa) diagrams are used to identify and address the root causes of problems and defects.

Heijunka: It is a production smoothing method which levels production to match customer demand, reducing fluctuations and improving the overall production stability.

Standard Work (SW): It documents the best-known way to perform a task, ensuring consistency and providing a basis for continuous improvement.

Visual Management (VM): Visual tools such as visual work instructions, performance boards, and charts that make it easier to monitor processes, identify issues and communicate information.

Gemba Walks (GW): Gemba refers to the actual place where work is done. Gemba walks involve leaders and manager going to the shop floor to observe processes. Gather insights and engage with employees.

It worthies to mention that these lean tools are not used in isolation but are often combined to create a holistic Lean system within an organization. The selection and application of specific tools depend on the organization's goals, processes and industry context. Lean tools help companies streamline operations, reduce costs, improve quality and become more responsive to customer needs and more competitive.

Lean Implementation in Furniture Industry

Wood waste refers to the small residual components that remain after various activities that are carried out in wood-related businesses such as sawmills, wood furniture industries, and pallet factories. These residues are created due to various factors. The composition of residues has a significant impact on the unit price of wood products, as well as the break-even point and the general economic situation of the wood furniture sector. Moreover, the effects of unit price of wood products on the economic condition, before and after the implementation of some technologies, have been demonstrated. By effectively implementing a simple process, it is possible to achieve lower unit costs, reduce the break-even point, and ultimately increase profitability (12). Researchers and practitioners have emphasized the implementation of Lean Manufacturing in the furniture business in developing countries. However, compared to the large amount of scientific work dealing with Lean adoption in industrialized countries, research in this specific context remains limited. A significant proportion of small organizations prioritize productivity enhancement, workplace organization, and space optimization as key goals for implementing Lean practices. On the contrary, non-Lean companies often attribute their failure to adopt Lean to challenges related to knowledge acquisition. By contrast, Lean companies see significant employee-related obstacles, including insufficient labor resources, limited implementation experience, and employee resistance to change. During the initial stages of Lean adoption, small organizations face difficulties in terms of technical knowledge, training opportunities, and financial resources. Further- more, the study identifies three specific simple applications applicable to the wood and furniture industry, namely, the 5S methodology, employee training, and quality control (10). A study by Rahman and others in (13) provides a critical assessment of the current limitations in Lean implementation within the wood and furniture industry, and highlight key areas for improvement. Many companies are actively seeking cost saving methods that do not include Lean Manufacturing. However, members of the Wood Component Manufacturing Association (WCMA) can benefit greatly from comprehensive Lean Manufacturing training, mentoring, and successful implementation initiatives. These efforts are essential to revitalize competitiveness and generate significant cost savings within the industry. Most notably, the WCMA shows an impressive rate of Lean Manufacturing. The study also reveals significant differences in tool adoption between organizations at different stages of Lean Manufacturing deployment, highlighting the importance of identifying key resources and benefits derived from Lean practices. In addition, the study sheds light on how these companies perceive and evaluate the impact of Lean Manufacturing on their operations. By emphasizing the importance of Lean Manufacturing and implementing it within the WCMA, companies can enhance their competitiveness and achieve significant cost reductions.

There are many other studies that have applied different tools of Lean in the furniture and wooden industry in the world. To name but a few, the reader can refer to 9 and (14-21). However, within the Palestinian context, to the best of our knowledge, no study has been published on applying Lean in furniture and wooden industry; a recent study by Araman and Saleh (22) investigated the application of lean six sigma (LSS)

methodology in implementing Lean Six Sigma: DMAIC methodology in aluminum profiles extrusion process in a local Palestinian company.

Study Objectives and Questions

This is centered around the application of Lean tools at the local furniture company. More specifically, the study aims at:

- Assessing the levels of awareness, implementation, effectiveness and the future use if Lean tools in furniture industry via a case study research approach.
- Applying set of Lean tools in the cabinet assembly department in the company.
- Measuring the improvement in the performance metrics in the cabinet assembly department.
- In accordance with these objectives, the study addresses answering the following respective research questions:
- What are the levels of awareness, implementation, effectiveness and the future use if Lean tools in furniture industry as perceived by the staff in the targeted company?
- How to apply the set of Lean tools in the cabinet assembly department in the company?
- What are the performance metrics in the cabinet assembly department before and after Lean tools implementation?

Research Methodology

Study of Data Collection Tool

The study adopted a quantitative research method for data collection. More specifically, a self-administered questionnaire has been designed to measure the level of awareness and implementation of Lean and its tools in the company. It also addresses the effectiveness of these tools as well as the future use of these tools in the company. A Likert scale having the following values (0 – do not know, 1 - low, 2 - very low, 3 - moderate, 4 - high, 5 – very high) has been adopted to measure both the awareness and implementation of Lean tools in the company. The questionnaire consisted of two sections. The first one includes some demographic information on the respondents who fill the questionnaire and the second section includes questions to measure the level of awareness and implementation of Lean as well as the effectiveness and the future use of these tools in the company.

On the other hand, Gemba walk study has been conducted and some Lean tools have been applied in the company to reduce the wastes.

Study Population and Study Sample

The number of employees working in the furniture company under study is 120. This represents the study population. Using Steven Thompson formula stated in (17), shown below, the sample size was calculated:

$$n = \frac{N \times p(1-p)}{[[N-1 \times (d^2 \div z^2)] + p(1-p)]}$$

Where, n= the sample size, N=population size (N=120), P=proportion of property offers and neutral (P=0.5), d=error margin (d=5%) and z= is the upper α/2 of the normal distribution (for 95% confidence level, z=1.96). Substituting the aforementioned parameter values in the above equation, the sample size equals n=92.

Data Analysis and Results

Descriptive Results

One hundred employees have been targeted to fill in the questionnaire, only 90 responded, and only 75 of responses were valid for analysis. Hence, a response rate of 90% was achieved, however, about 82% of the needed sample were valid for analysis. Before presenting the descriptive results of the demographic profiles of respondents as well as the levels of awareness and implementation of Lean in the company, we present the results of consistency and reliability of data as measured by the Cronbach's alpha. The results revealed a Cronbach's alpha of 0.88 for awareness of Lean tools and a value of 0.82 for implementation of Lean tools. In both cases, as the values are greater than 0.60, then consistency and reliability are confirmed (23). With regard to the demographic profiles of the respondents, the results revealed that 13% of the sample represented the management levels in the factory, 16% were from the design department and the rest 71% were from the workers in the company. In regard to work experience, the results revealed that 23% of sampled staff have experience between 1 to 5 years, 33% have between 6 and 10 years and 44% have more than 10 years of working experience. Finally, with respect to age categories, the results showed that about 20% of the respondents are in the age category 20-30 years, 40% are in the age category of 31-40 years and the rest have ages more than 40 years.

Results of Awareness and Implementation of Lean Tools

The respondents were asked to answer questions on the awareness of each of the Lean tools mentioned previously using the adopted Likert scale. Figure 2 shows the awareness level of lean tools and techniques by the sampled staff in the company. 5S was ranked the highest with the mean score of 3.89. The second was JIT (3.66), followed by Kaizen (3.58), SW (3.46), PDCA (3.45), VSM (3.45), TPM (3.42), and VM (3.2). The rest of tools have average level of awareness less than 2 as depicted in the figure. From the results, it can be seen that most of the staff in the company were aware of 5S and they understood the concept of 5S in order to help to reduce waste successfully. Moreover, 5S is also known as the basic tool for lean implementation. The gross average of awareness is 2.76, which is equivalent to moderate level of awareness.

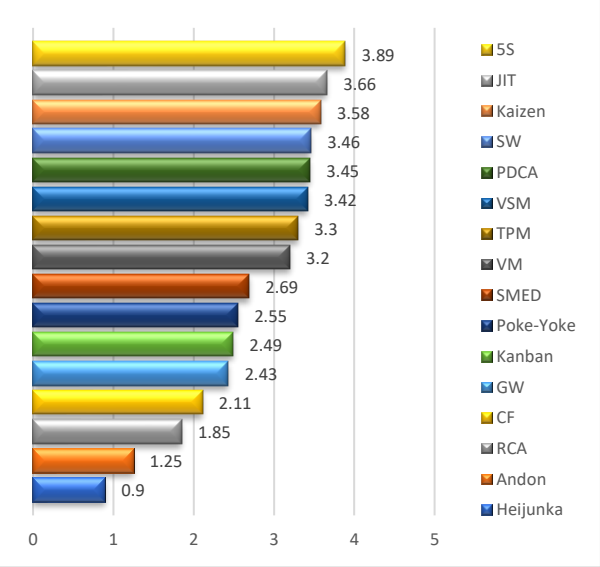

Figure (2): Lean tools awareness levels.

Similarly, the respondents were asked to answer questions on the awareness of each of the Lean tools mentioned previously using the adopted Likert scale. Figure 3 shows the implementation level of lean tools and techniques by the sampled staff in the company. 5S was ranked the highest with the mean score of 4.23. The second was PDCA (4.11), followed by SW (3.90), VSM (3.85), Kaizen (3.45), VM (3.2), GW (2.5), TPM (2.33), CF (1.55) and RCA (0.5). The rest of tools are not implemented in the company. From the results, it can be seen that most of the staff in the company are implementing 5S as they understood the concept of 5S in order to help to reduce waste successfully. 5S is also known as the basic tool for lean implementation. The gross average of implementation is 1.85, which is equivalent to low level of implementation.

Results of Effectiveness and the Future Use of Lean Tools

The respondents were asked to give their perceptions on the effectiveness of the implemented Lean tools (depicted in Figure 3) using the adopted Likert scale. Figure 4 shows the effectiveness levels of lean tools and techniques by the sampled staff in the company. The gross average of effectiveness is 3.59 which is of high level. On the other hand, the respondents were asked to report their perceptions on the future use of Lean tools. Figure 5 shows the results.

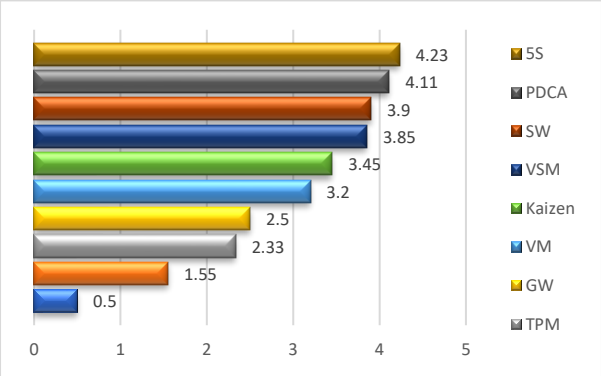

Figure (3): Lean tools implementation levels.

They agreed that 5S, JIT, CF, Kaizen and PDCA occupy the priority in their future use, followed by other tools as shown in Figure 5. The gross average of future use of Lean tools is found to 3.30 which of moderate level and is greater than the current level of implementation (1.85) of low level. Hence, this intention in employing more Lean tools in the future is an evidence that the staff believes in the benefits of applying Lean tools in furniture industry.

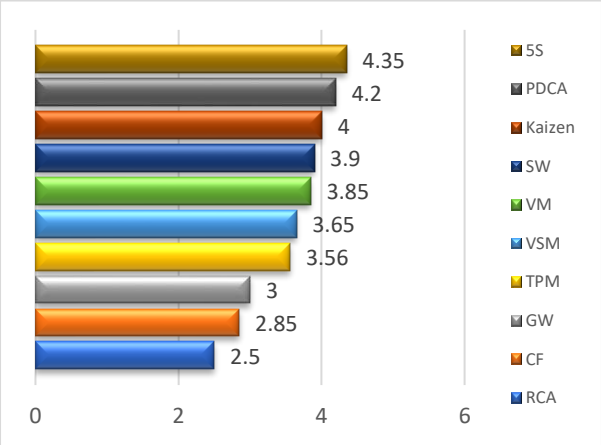

Figure (4): Lean tools effectiveness levels.

A Real-Case Application of Lean Tools in Furniture Industry

In accordance with results in Figure 5, we chose the first three tools (5S, JIT and CF) and conduct a real application of these tools in the company to prove their effectiveness in waste reduction and process improvement. Below, we elaborate more on these tools (11).

5S Methodology: The "5S" methodology encompasses a structured approach encompassing 5S: Sort, Set in Order, Shine, Standardize, and Sustain. This process entails meticulous evaluation of items within a designated space, discerning essential from non-essential elements. It involves meticulous organization, promoting a systematic arrangement. Furthermore, emphasis on cleanliness is integral, augmented by the establishment of standardized procedures. The crux of the "S Rule" lies in the efficient execution of these steps within the workplace. Table 1 summarizes the 5S methodology (11).

Just-In-Time (JIT): The JIT inventory system is a strategic approach aimed at synchronizing the arrival of goods with their precise requirement. For instance, in the context of a car assembly plant, airbags are not pre-stocked, but rather received only when they are needed during the assembly process.

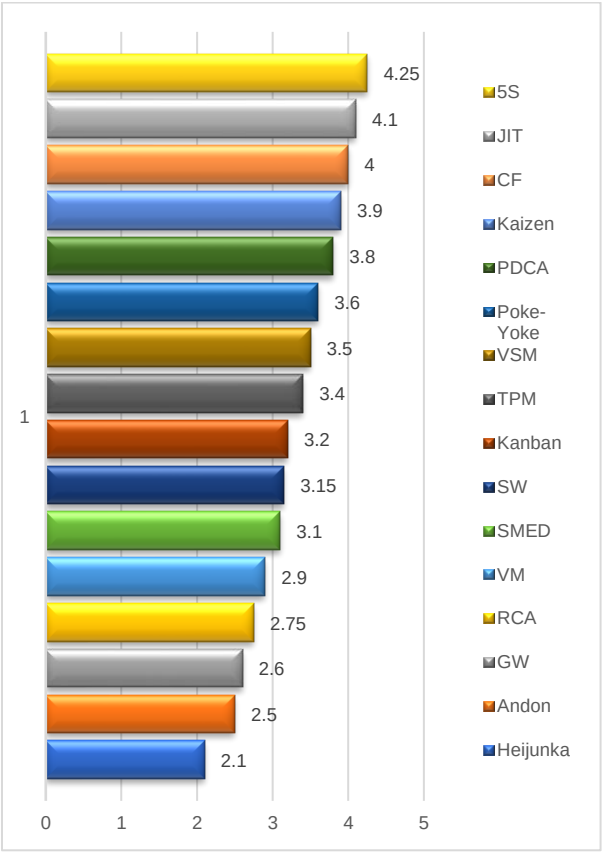

Figure (5): Future use of lean tools.

Continuous Flow (CF): CF signifies a streamlined process where parts are sequentially transferred from one operation to another without any intervening work-in-process inventory. This can be achieved either by moving a single piece at a time or in small, manageable batches.

The authors in cooperation with a three-team member from the company's staff has conducted a detailed study via Gemba walks in the company. Table (2) summarizes the main observations, before implementing any Lean tools in the

company, the research team could come up with as a result of their Gemba walks.

Table (2) demonstrates the conditions of the furniture industry before implementing lean practices, wherein various tools and techniques were observed, along with their corresponding drawbacks. During the assembly process, the sorting of work-in-progress (WIP) aimed to enhance efficiency but led to wasted motion, increased assembly durations, and the risk of waiting due to machine availability.

The avoidance of batch production resulted in recurring quality issues, longer assembly lead times, waste from handling the same piece multiple times, and space limitations. Implementing batch flow for cleaning wooden pieces after edge banding introduced quality problems, waste, and underutilization of resources. While horizontal storage of wood items reduced waste, it also caused quality concerns, ergonomic problems, longer assembly lead times, and space restrictions. The adoption of a continuous flow approach resulted in motion waste, underutilized re- sources, machine waiting time, and waste from handling. The labeling process lacked standardization and contained limited data, which led to prolonged search times and extended lead times. These observations shed light on the difficulties faced by the furniture industry prior to the implementation of lean principles. Before implementing any Lean tools, the team gathered random nine-day data related to producing and assembling wooden cabinets in the company during one month of production.

Table (1): The 5S methodology.

The 5S Phases	Definition
Sort	This step involves identifying and removing tools and items that are no longer needed or used in order to streamline operations and make the workflow more efficient
Set in order	During this step, arrangements are made in the workspace to ensure that everything is easily accessible. This includes organizing tools, equipment, and materials in a way that promotes productivity and minimizes wasted time searching for items.
Shine	The shine step emphasizes the importance of maintaining a clean and dust-free working area. Regular cleaning and maintenance tasks are carried out to ensure a safe and pleasant work environment.
Standardize	In the standardize step, practices such as implementing color coding and clear labels for each item are established. This promotes consistency and clarity, making it easier for employees to find and use tools or materials as needed.
Sustain	The sustain step emphasizes the involvement of all employees and their commitment to continuous improvement. Sustaining a Lean environment requires ongoing efforts to maintain the 5S practices and foster a culture of continuous improvement throughout the organization. It's important to note that the participation of all employees is crucial for the success and sustainability of Lean practices, as it requires a collective effort to embrace and uphold these principles.

The collected data are summarized in Table 3. We could analyze the following information:

Waste (kg): The waste produced during the assembly process is documented in kilograms (kg). The data revealed varying amounts of waste each day, ranging from 2.8 kg to 9.0 kg per day, with an average of 4.80 kg per day.

Number of Workers: This column indicates the number of workers engaged in the assembly process. The data suggested that the number of workers ranges from 6 to 9 throughout the month, with an average of 7.556 workers per day

Time to Assemble (min): This column represents the duration required to assemble the quantity of cabinets produces, measured in minutes. The recorded values vary between 121.5 minutes and 315.9 minutes, with an average of 205.2 minutes per day or equivalent 3.42 hours per day.

Table (2): Before Lean implementation.

Issue	Observation	Effects
Work-in-Process (WIP)	Sorting out drawers during assembly is a task that involves organizing and arranging the contents of drawers as part of the assembly process. This step ensures that items are properly sorted and easily accessible, improving efficiency and productivity during assembly	Waste of motion Longer assembly times Risk of waiting due to the availability of the machine
Avoiding Batch Production	The company does not produce in batches as their manufacturing strategy is make- and assemble-to-order not make-to-stock as the products are not standard; rather they are customizes	Poor quality might be repeated. Long assembly lead time Waste of handling the same piece more than one time Space problems.
Batch Flow	Cleaning wooden pieces after edge banding is an essential step to ensure the final product's quality and appearance. After edge banding, there may be excess glue, dust, or residue on the wooden pieces that need to be thoroughly cleaned	Poor quality Handling waste challenge Unutilized resource
Waste Reduction	Wood items are stored horizontally.	Poor quality might appear Ergonomics problems Long assembly lead time and handling Space problems
Continuous Flow (CF)	Items requiring second edge banding are being transferred manually to the beginning of the machine. There are 3 edge banding machines running while there is only one boring machine which creates bottleneck at the boring machine. There is no standard location for placing information labels. Labels contain limited data	Motion waste Unutilized resource Machine waiting time Handling waste Long searching time. Long lead time

Table (3): Data collected over a month before Lean implementation (a N/A: not applicable).

Waste (kg)	No. of workers	Time to assemble (min)	No. of Cabinets	Day.#
5.0	8	243	10	1
6.0	6	218.7	9	2
8.0	8	194.4	8	3
9.0	6	315.9	13	4
3.3	8	194.4	8	26
3.2	8	145.8	6	27
3.0	7	194.4	8	28
2.9	9	121.5	5	29
2.8	8	218.7	9	30
Average (per day)				
4.80	**7.556**	**205.2**	**8.444**	**N/A[a]**

Number of Cabinets Assembled: The quantity of cabinets assembled each day is listed in this column. The data indicates that the number of cabinets assembled ranges from 5 to 13 units per day with an average of 8.444 cabinets per day.

Day. # in the Month: This column signifies the specific day of the month when the data was collected.

By examining this data, we can observe the fluctuating nature of waste generation, the varying number of workers involved, the range of assembly times, and the daily output of cabinets. These variations underscore the necessity for process improvement and the potential benefits of implementing Lean tools. By streamlining operations, reducing waste, optimizing resource utilization, and enhancing productivity, the company can experience significant improvements. Based on the average values computed in Table 3, we could find the following monthly averages, provide that workers work 26 days per month, 8 hours per day:

- Average monthly waste per worker = (4.800/7.556)x26=**16.52 Kg/worker**
- Average monthly waste per cabinet = (4.800/8.444)x26=**14.78 Kg/cabinet**
- Average time to assemble a cabinet=205.2/8.444=**24.30 minutes/cabinet**
- Average time one worker utilizes in assembling one cabinet =205.2/7.556=**27.157 minutes/cabinet-worker**
- Average utilization of time in assembly by one worker =(27.157)/(8x60)=**5.66%** of workers time utilized in assembly
- Average no. of cabinets assembled monthly =8.444x26=**219.544** cabinets/month

Next, the team applied the following Lean tools as well as some other practices to improve the performance in the cabinet assembly department. More specifically, firstly, the 5S methodology have been applied in the assembly department. Figure (6a-6d-) shows the “before 5S” and “after 5S” states in the assembly department.

Figure (6a): Before sort & set- in-order phases.

Figure (6b): After sort & set-in-order phases.

Figure (6c): Before shine phase.

Figure (6d): After shine phase.

In order to standardize, roles and responsibilities must be clearly and consistently applied. This can be accomplished through visual controls such as color-coding, flow charts, checklists, and labeling to help reinforce a uniformed approach. Figure 7 shows the assembly department before and after painting.

Figure (7a): Before painting work cells (the 4th S).

Figure (7b): After painting work cells (the 4th S).

Company's management auditing process should be put into practice to make sure that employees understand that maintaining the level of workplace organization is a top priority. Management audits should focus on ensuring that the routines and schedules specified in S4 (Standardize) are being properly maintained. The audit also provides a good opportunity for asking questions and providing suggestions that encourage further improvements. Table 4 summarizes the 5th phase (sustain) of the 5S methodology. After implementing the 5S methodology, the team applied the JIT system. More specifically, the recommendation was to receive ready-for-assembly products, which led to several advantages. These include decreased rework, minimized product handling, reduced motion waste, shorter assembly lead time, and clear accountability. Implementing JIT also resulted in decreased motion waste from machine walking, reduced waiting time, fewer instances of handling assembly pieces, and improved utilization of skilled labor in the assembly team. Then, the team applied the continuous flow (CF) tool. More specifically, the recommendation involved transitioning to a one-piece flow production system. This change brought about a 30% increase in productivity, a 70% decrease in assembly lead time, a significant 70% reduction in required space, and improved utilization of skilled labor in the manufacturing team. The implementation also led to reduced overall lead time, fewer instances of product handling, and minimized quality issues. Also, the team recommended the full activation of machines where the recommendation focused on fully activating machines to obtain ready parts without excess adhesive material. This resulted in a 20% reduction in human resource requirements, decreased manufacturing lead time, reduced waiting time, fewer instances of handling pieces, and improved utilization of skilled labor in the manufacturing team.

Table (4): Sustain phase job aid summary.

Definition - Sustain The process of keeping the 5s running smoothly in addition to the involvement of all employees.	**Target Outcome:** To start noticing positive continuous outcome.
Action Steps: Monitor and follow up processes established during S4 – Standardize. Expand 5S efforts to other work areas. Evaluate 5S effectiveness and improvement. Recognize and reward strong efforts.	**Resources:** Management audit forms. Resources for communication and recognizing successes (newsletters, displays, awards). Management commitment and focus on keeping the new standards.
Progress Check: Sustain methods clearly defined, with roles and target dates identified. Sustain actions implemented, for example: 5S teams share idea and benchmark with each other. 5S teams present projected results within the company and to others. 5S team results published in company communications. 5S teams visit another different companies to get new ideas. Company leaders perform 5S audits to see accomplishments and opportunities. Diversified visual aids. Continuously improving the company's 5S approach through generating ideas.	
Tips: Establish a calendar for sustaining activities and keep on it. Make it part of the company's operating discipline. Involve all employees in sustaining 5S improvements, share them in evaluating areas outside their workplace, providing support for other workplaces, and that excel in visiting other companies. Establish a 5S resource center to provide teams 5S supplies so that they can easily sustain and continuously improve their 5S results.	

Besides, a vertical storage system was recommended in which wooden parts related to a specific project were stored vertically on a specialized trolley. This approach brought several advantages, including reduced lead time, decreased product handling, reduced searching times, minimized quality issues, and reduced space requirements. The implementation of these Lean tools and recommendations yielded significant benefits, including a 50% reduction in searching waste, elimination of sorting out pieces during assembly, improved utilization of skilled assembly teams, enhanced ergonomics, and space savings. Overall, the implementation of Lean principles in the furniture industry resulted in improved efficiency, reduced waste, optimized resource utilization, and enhanced productivity. Table

5 summarizes these applications. After Lean implementation, the team collected a new set of data to measure the performance of the assembly department. Similar to the setting employed before Lean implementation, the team collected data shown in Table 6.

Table (5): After Lean implementation.

Tools	Recommendation	Advantages	Realized Benefits
JIT	Receive ready-for-assembly products.	Less rework. Less handling of products. Less motion waste. Less Assembly lead time. Clear responsibility.	Less motion waste due to walking to the machine. Less Waiting time. Decreased number of times handling the assembly pieces. Higher utilization of the skilled labor of the assembly team.
Continuous Flow	Move to one-piece-flow production system.	30% increase in productivity. 70% less assembly lead time. 70% less required space. Higher utilization of the skilled labor of the manufacturing team.	Assembly structure is according to the batch production. Less lead time. Less number of times handling the products. Less poor quality issues.
Fully activate the machine to get ready parts without the excess adhesive material.	Human Resources Reduction by 20% Less manufacturing Lead time. Less Waiting time. Decreased number of times handling the pieces. Higher utilization of the skilled labor of the manufacturing team.		
Place all wooden parts related to certain project vertically on a special trolley.	Less Lead time. Less number of times handling the products. Less searching times. Less quality issues. Less Space.	Searching waste was reduced by 50%. Avoid sorting out pieces during assembly. Higher utilization of skilled assembly team. Better ergonomics. Space savings.	

Upon analyzing the data shown in Table 6 collected over a month following the implementation of Lean principles, we have the following discussion:

Waste (kg): The implementation of Lean practices has led to a noteworthy decrease in waste generated during the assembly process. The data demonstrates reduced waste levels, ranging from 2.0 kg to 4.5 kg, with a daily average of 2.756 kg per day

Number of Workers: The number of workers involved in the assembly process remains stable at 6 throughout the entire month, indicating a consistent requirement for the workforce and suggesting workforce stability.

Time to Assemble (min): The time required to assemble a cabinet has also shown improvements after the adoption on of Lean principles.

Table (6): Data collected over a month after lean implementation (a N/A: not applicable).

Waste (kg)	No. of workers	Time to assemble (min)	No. of Cabinets	Day.#
2.3	6	159.12	16	1
2.2	6	172.38	17	2
2.2	6	159.12	16	3
2.1	6	198.9	20	4
4.0	6	106.08	10	26
4.5	5	172.38	17	27
2.5	3	106.08	10	28
2.0	6	119.34	12	29
3.0	6	92.82	9	30
Average (per day)				
2.756	**5.556**	**142.9**	**14.11**	**N/A[a]**

The recorded values range from 92.82 minutes to 198.9 minutes, with an average of 142.9 minutes per day or equivalently with 2.38 hours per day, indicating a reduction in assembly time.

***Number of Cabinets Assembled*:** The number of cabinets assembled per day remains relatively consistent, varying between 9 and 20 units per day, with an average of 14.11daily cabinets. This indicates a steady production output, suggesting that the Lean implementation has increased the daily production volume.

Day. # in the Month: This column represents the specific day of the month when the data was collected.

The analysis of the data following the implementation of Lean tools reveals several positive changes. More specifically, there is a significant reduction in waste generation, indicating enhanced efficiency and improved waste management in the assembly process. The consistent number of workers suggests a stable workforce, which can lead to better coordination and productivity. The reduced time to assemble cabinets further indicates increased efficiency and productivity. Based on the average values computed in Table 3 and Table 6, we could find the following monthly averages, provide that workers work 26 days per month, 8 hours per day:

- Average monthly waste per worker = (2.756/5.556) x 26 = **12.897 Kg/worker**.
- Average monthly waste per cabinet = (2.756/14.11) x 26 = **5.078 Kg/cabinet**

- Average time to assemble a cabinet = (142.9/14.11) = **10.127 minutes/cabinet**
- Average time one worker utilizes in assembling one cabinet = (142.9/5.556) = **25.72 minutes/cabinet-worker**
- Average utilization of time in assembly by one worker =(25.72) / (8x60) = **5.36%** of workers time utilized in assembly
- Average no. of cabinets assembled monthly = 14.11 x 26 = **366.86 cabinets/month.**

The data strongly suggests that the implementation of Lean tools has resulted in improved performance indicators, including reduced waste, consistent work- force requirements, shorter assembly times, and steady production output in the furniture industry. Table 7 summarizes the waste and assembly metrics before and after lean implementation and the improvement rates. Overall, this comparison highlights the significant improvements resulting from Lean implementation, including waste reduction, workforce stability, shorter assembly times, and potentially increased production output. These changes indicate the positive impact of Lean tools on the efficiency and performance of the furniture industry.

Discussion

As shown in the previous section, the study questions have been successfully addressed and answered. More specifically, in regard to question one, the results show moderate levels of Lean awareness and low level of general implementation in the furniture industry. However, it has been proved that the applied Lean tools in this industry has a high level of effectiveness, whereas the industry perceives a moderate level of the future use of these tools in the future.

Table (7): Comparison between before and after lean implementation.

Metric	Before	After	Rate of Improvement [a]
Average monthly waste per worker	16.52	12.897	21.9%
Average monthly waste per cabinet	14.78	5.078	65.64%
Average time to assemble a cabinet	24.30	10.127	58.32%
Average time one worker utilizes in assembling one cabinet	27.157	25.72	5.30%[b]
Average utilization of time in assembly by one worker	5.66%	5.36%	5.30%[c]
Average no. of cabinets assembled monthly	219.544	360.86	64.37%

a: *rate of improvement={(value before-value after)/value before}x100%*

b &c: as assembly is value-adding time, significant improvement is not expected as required by the assembly operations and quality requirements

These results are in line with (17) who conducted a study to assess the awareness and effectiveness implementation of Lean tools in Malaysian organizations. However, their study differs from our study, basically, in the order of Lean tools employed in the Malaysian organization, but, as shown in our results, the 5S methodology came in the first place of awareness, implementation, effectiveness and future use. There are differences between our and their results in the order of other Lean tools. This is mainly attributed to the study population in both studies; out study is a case study in furniture industry, but in their study, they considered different manufacturing sectors. In the sequel, their results are more general to the manufacturing sectors, however, our results could be generalized to the furniture industry only. In regard to the questions two and three, a real-case application of some Lean tools (namely, 5S, JIT and CF) with other actions has been successfully validated in the cabinet assembly department in the company under investigation. The results revealed a substantial improvement of process performance as measured in reduction of wastes, reduction in time to assemble, more labor utilization and more productivity. These results agree with the results of other works on implementing Lean tools in the furniture industry and other industries; namely, (15), (18-19) and (22).

Theoretical and Practical Implications

This study provides a comprehensive assessment of Lean implementation in the furniture industry context at a Palestinian company. The study examines the different underlying techniques used to implement Lean principles, emphasizing their role as implementation tools rather than independent determinants of success. While these techniques, such as 5S, PDCA, Just-in-Time (JIT) and continuous flow among others, are essential to the Lean transition, their effectiveness depends on participation. employees and their commitment to fostering a culture of continuous improvement. Notably, the analysis emphasizes the central role of employee involvement in Lean practice, emphasizing that its success depends on collective efforts to uphold Lean principles. The empirical basis of the study is evident in the presentation of the collected data, including surveys and statistical analysis. The study shows how Lean implementation has a positive impact on waste reduction, production efficiency and resource optimization. To complete this analysis, several strategic recommendations emerge. It is suggested that Lean principles must align with the overall strategic goals of the company in order to emphasize the company's contribution to sustained success. Additionally, cultivating employee engagement and engagement is key to fostering a culture of continuous improvement. The study acknowledges unique regional and cultural considerations in Palestine, adding depth to the analysis by highlighting potential influences on Lean implementations. Continuous learning, skills development and training initiatives have been identified as imperative to enable employees to actively contribute to waste reduction and process optimization. The analysis highlights the iterative nature of lean implementations, favoring a process of continuous learning, adaptation, and improvement. The study recognizes the importance of data-driven measurement through identifying and tracking Key Performance Indicators (KPIs) to assess the impact of Lean practices. By encapsulating these ideas within a scientific framework, the analysis not only sheds light on the successful implementation of Lean in the Palestinian furniture industry, but also provides a roadmap for future research and continuous improvement in Lean practices. Following the introduction of lean tools in the workshop, notable outcomes were observed. Firstly, through the implementation of Just-in-Time (JIT) practices, there was a significant reduction in work-in-progress (WIP), leading to substantial cost savings. The average cash-flow savings amounted to 600,000 JD, based on

the assumptions that each kitchen project had an average price of 7,500 JD, with a total of 80 projects. Addition- ally, the space required for holding materials was efficiently minimized from 400 m2 to less than 240 m2. Furthermore, the average waiting time experienced by customers was reduced to a mere 4 months. Moreover, the implementation of lean tools in the workshop resulted in additional waste reduction. Transportation waste, for instance, experienced a notable decrease of 120 meters for each project, streamlining logistical operations. Furthermore, labor waste was successfully addressed through lean principles, leading to two laborers saving 10 minutes for each project, optimizing productivity. In summary, the application of lean tools in the workshop produced significant positive outcomes. These included substantial cash-flow savings, reduced space requirements, shorter waiting times for customers, decreased transportation waste, and improved labor efficiency. These findings highlight the effectiveness of lean principles in enhancing waste management practices and overall operational efficiency in the examined Palestinian company. Accordingly, the study results contribute theoretically to the theory of Lean philosophy and principles by enhancing their importance in industries by adding one more application of these tools in emerging counties. It also offers practical implications to policy and decision makers in the wooden and furniture industry about the awareness, implementation, effectiveness and the future of these tools in the industry as perceived by people working in this industry.

Conclusions

Lean tools are essential in various industries because they offer a systematics and structure approach to improve processes, eliminate waste, enhance productivity and achieve better outcomes. In the dynamic and competitive landscape of the furniture industry, the adoption of Lean tools represents not only a strategic advantage but a commitment to excellence. Embracing Lean principles within this industry is motivated by a deep understanding pf the transformative benefits it can bring to companies, customers and the industry as a whole. To this end, study focuses on assessing the levels of awareness, implementation, effectiveness and future of Lean tools in furniture industry in Palestine. More specifically, a local company in furniture industry of 120 employees has been selected for study to answer our research questions. The perceptions reported by a sample of the employees have been collected via a self-administered questionnaire, carefully filtered and statistically analyzed. The results revealed moderate levels of awareness and future use of Lean tools in the industry, however, the industry still in low levels of Lean tools implementation while the effectiveness of the applied tools is proved to be high. To translate this high effectiveness of implemented tools on the performance motivated us to consider one of the important departments in the company; the cabinet assembly department for further investigation. Monthly data before Lean implementation has been collected and state of the performance in the department has been quantitatively analyzed where some performance metrics have been determined. Then, one month later, three important Lean tools (namely, 5S, JIT and CF) with other improvement actions, have been implemented in the department, new data on the performance has been collected and analyzed. The analysis showed substantial improvements in performance, specifically, less wastes, less assembly and hence less delivery time, more workforce utilization and more productivity. These improvements collectively reduce the cost of manufacturing in the company and ultimately enhance the competitiveness of the company as well as boost customer satisfaction. As common in most of case study-based works, this study has its own limitations. Firstly, the study considers only one furniture industry in Palestine. It would be better if further researches consider the whole sector of wooden and furniture industry in Palestine. Secondly, the application of only three Lean tools (5S, JIT and CF) have been employed in one department in the company for performance improvement. As a future extension, researchers are encouraged to consider more tools and other departments for investigation. Finally, a general recommendation is to consider studying the challenges, barriers, opportunities and future use of Lean tools in other manufacturing and service sectors in Palestine.

Ethics approval and consent to participate.

Not applicable

Consent for publication

Consent for publication is accepted by authors to publish the manuscript including Tables and Figures.

Availability of data and materials

The raw data required to reproduce these findings are available in the body and illustrations of this manuscript.

Author's contribution

The authors confirm contribution to the paper as follows: study conception and design: all authors. Data collection: Baraa Hakawati and Hamed Al-Hamadneh. Data analysis: Baraa Hakawati and Yahya Saleh. All authors reviewed the results and findings. First draft of the manuscript preparation: all authors. Revising the manuscript: Yahya Saleh.

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