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The Impact of 5S Strategy on the Safety Climate & Productivity at Egyptian Garment Firms (Assembly Plants)

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Abstract

5S is one of the lean manufacturing tools that helps organizations to improve the work environment. The philosophy of 5S interesting on eliminating waste and non-value activity which increases labour efficiency and work area safety. Although many articles stated the significant impact of implementing lean manufacturing in worker environment, non-quantifiable results were reported. In this article, the impact of the 5S event on the safety climate and productivity at the assembly plant of Egyptian garment firms was studied. The sample was divided into two groups based on 5S implementation. The Safety Climate Assessment Tool survey (SCAT) was used in measuring the perceptions of safety on a Likert-scale while three productivity metric was calculated. The result presented that 5S has a significant impact on 7 of 8 topics of safety climate. The management commitment & the priority of safety climate at Egyptian garment firms need to be developed while usage a no-blame approach to persuade people acting safely has to be increased. In the same context, the results assigned that productivity measures influenced by 5S event.

Keywords

Lean Manufacturing, 5S Event, Safety Climate, Productivity Measures, Egyptian Garment

1. Introduction

Manufacturers face several challenges, e.g. rising costs, inefficiencies, and low of quality and safety by implementing process improvement techniques. Lean is a well-established set of principles which aim at reducing waste. It is used prominently due to its effectiveness and simplicity.

Lean, in theory, is supposed to improve the working conditions of the employees and eliminate the hazards in the workplace as well [1]. There are even a few instances where researchers have shown improvements in occupational safety through lean, but they are limited [2]. Basically due to other critical issues like delivery, quality and customer satisfaction, occupational safety is lost. Therefore provide evidence of lean affecting occupational safety is required.

The target of this study is to seek the potential relationship between lean and safety climate of assembly workers. 5S is the lean technique investigated in this study. The subject area is the assembly department at a manufacturing facility.

2. Literature Review

2.1. Lean Manufacturing

Although the origin of the lean manufacturing traced to the early days of Ford Motor Company, the development came by the Japanese automobile industry after World War II. Lean manufacturing defined by Toyota motor as a management philosophy with a set of tools which attend to eliminate waste, reducing costs and improving quality [3]. In addition, the lean methodology aims to improve the value as perceived by customers by ensuring timely service or delivery. Table 1 demonstrates the seven wastes which were mentioned in the Toyota Production System (TPS) [4].

By the times, the application of lean principles from the Toyota Production System has developed to a more customer value orientation. Definition of value related to the capability of the organization to achieve customer requirements in minimal time. In this respect, the value was divided into two sections as added-value and non added-value. Added-value identified as critical steps in serving and delivering products to a customer while non added-value should be removed

Table 1. 7^{th} wastes in manufacturing from TPS.

Wastes	Description
Overproduction	Producing too much or too soon, resulting in poor flow of information or goods and excess inventory.
Inventory	Excessive storage and delay of information or products, resulting in excess inventory and costs, leading to poor customer service.
Motion	Poor workplace organization, resulting in poor ergonomics, e.g., excessive bending or stretching and frequently lost items.
Transportation	Excessive movement of people, information or goods, resulting in wasted time and cost.
Inappropriate processing	Going about work processes using the wrong set of tools, procedures or systems, often when a simpler approach may be more effective.
Defects	Frequent errors in paperwork or material product quality problems resulting in scrap and/or rework.
Wasting	Long periods of inactivity for people, information or goods, resulting in poor flow and long lead-times.

[5]. This results in placing customer value and waste reduction at the centre of lean [6]. Lean in manufacturing facilitates streamline operations, decreasing the lead time, inventory and eliminating wastes, in beside that its focus on increasing financial savings and customer satisfaction [6] [7]. Recent researches have cited that organizations have realized enormous achievements due to implementing lean principles. Reference [8] stated that executing lean manufacturing lead to improving performance in terms of productivity and quality. This clarifies the potential of improving quality while simultaneously decreasing the cost of manufacturing facilities.

2.2. 5S Lean Manufacturing

5S is a powerful lean procedure which improves work environment through eliminating waste and non-value activities consequently, increase the product quality and employees morals. Some researchers identify it as a system which help workers to think differently, while others see it as an organizer tool, however they all agree that it's an effective & simplest lean manufacture [9] [10].

5S translated from five Japanese principles that start with the letter "S" to five equivalent English words as Sort, Set in order, Shine, Standardize, and Sustain [9]. **Figure 1** presents the principles of 5S.

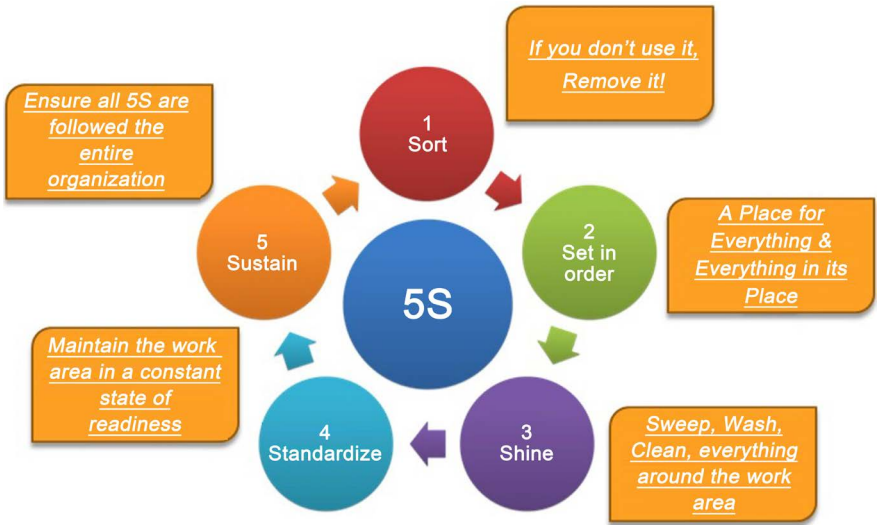
Description of the 5S Program

According to [8], 5S is a technique where waste is eliminated as well as productivity and quality are improved through organizing the work area.

1S: Sort: Concentrates on segregated between necessary and unnecessary items at work area.

2S: Set In Order: focuses on place the collected items from previous S "sort" in its proper location which help in saving time (Lead Time).

3S: Shine: Interest in maintaining the production area. After implementing



Source: Redesign by author.

Figure 1. 5S principles.

the first two elements eliminate waste and locate the needed items, the shine step began to clean the work area.

4S: Standradize: Aim to allow employees to implement the best practices in the entire organization by standardizing methods.

5S: Sustain: Sustain is almost considered as the most difficult "S" to implement, as many employees tendency to return to the old way of doing things. Sustain step emphasis on maintaining the whole system by the meaning of accountability, commitment and empowering.

Benefits of a 5S program

- Magnify visibility.
- Eliminate waste.
- Increase sense of ownership & morale.
- Improved productivity—minimizing the time spent searching for tools, materials, etc.
- Save time (Lead time).
- Improved quality, maintenance & safety.
- A better impression on customers.

2.3. Safety Climate

Several industries such as construction and aviation give careful consideration to evaluating safety [11]. Basically, safety assessment had been based on reactive measures (reported data on worker fatalities and injuries). However, human factors & organizational are involved in different incidents. So currently, many industries are interesting on predictive measures of safety [11]. Safety climate regarded as a predictive measure of safety, than others traditional safety measures which are reactive [12].

Most of the researchers have been defined safety climate in terms of worker attitudes towards safety. Reference [13] stated that safety climate returns to safety habitude of employees in a working plant, while according to [14], safety related to employees perceptions toward procedures and practices in an organization (reflect the value of safety).

Generally, the term of safety culture utilized in an integrated way with safety climate despite they have varied perceptions and have been studied individually [12]. While security culture points to the general convictions existing in an establishment, safety climate is more identifying to attitudes and employees perceptions' for both internal and external impacts [15]. Reference [16] signified that the safety climate is a more proper term for the investigations from the surveys.

Safety Climate in Industrial

Safety climate is viewed as the best instrument for estimating work safety environment in manufacturing facilities. Reference [17] referred to that the regular strategies for estimating safety are incomplete and others different components are wanted to genuinely comprehend the safety in a work environment. Employees' perceptions, safe practices, management commitment are imperative

parts to be comprehended to understand the general significance of safety in the manufacturing segment. Therefore, Safety climate measuring tool, which includes all these elements, acquires a great importance.

Safety climate measuring tool was evolved by several researchers in order to include varied dimensions for measuring the employees' perceptions of safety. In fact, there is no particular safety survey, which is considered the most effective measuring tool due to their relevant models which differ from manufacturer to others [18] [19] [20] [21]. In this study dimensions like safety rules & procedures, management role, worker empowering are extremely important due to the fact that they may be impacted by implementing 5S. Therefore, according to the prerequisites, the safety climate survey utilized in this article is the Safety Climate Assessment Toolkit (SCAT) which was produced by the UK Health and Safety Executive (HSE) [22]. This was initially produced for oil extraction organizations, but over time became one of the standout amongst the most ordinarily connected polls in the manufacturing industries too [23].

2.4. Safety & Lean

The lean concepts of eliminating waste, optimizing the process flow, and increasing the quality lead to reduce work area hazard and improve safety [24]. Although several researchers presented the significant impact of implementing lean manufacturing in worker safety, non-quantifiable results were reported. This ultimately fails in substantiating the real relationship between lean and worker safety.

3. Methodology

The research was performed in the assembly area at Egyptian garment establishments. The sample was divided into two groups based on 5S implementation according to [25]. Group (A) (the most applicable to 5S event) represented 52.9% of the total sample while group (C) (the lowest applicable) 47.1%. The statistical analysis based on comparing collected data of the safety climate from two groups while the productivity measures were calculated.

3.1. Safety Climate Survey

The Safety Climate Assessment Tool survey (**Appendix**) was used in this investigation. The SCAT contains 43 questions with 8 different topics (**Table 2**).

The perceptions of safety were measured on a Likert-scale (**Table 3**). T-tests with a difference in the SCAT scores (Final Score & Section wise scores) were analyzed with 0.05 level of significance.

3.2. Productivity Measures

The effectiveness of the 5S event was tested using three productivity measures.

3.2.1. Cycl Time

The cycle time in this study was estimated by time study, using a stopwatch (or a

Table 2. Different topics of SCAT.

Topics	Items
Management Commitment	7
Communication	5
Priority of Safety	7
Supportive Environment	6
Involvement	3
Personal Priorities and Need for Safety	5
Personal Appreciation of Risk	4
Work Environment	6

Table 3. Safety climate survey scale.

Rating	Scale
Strongly Disagree	1
Disagree	2
Neutral	3
Agree	4

phone). Using the accessible data, the actual number of cycles to be measured was computed using Equation (1).

$$N = \left(\frac{Z \cdot S}{E} \right)^2 \quad (1)$$

where,

N = Final number of cycles to be observed.

Z = Value from the Z table (Z = 1.96 for 95% confidence interval).

E = Accuracy (±5%) × Average cycle.

S = Standard Deviation of the cycle time.

3.2.2. Floor Space

A successful 5S event usually frees the available floor space previously held up by unnecessary items. Increased floor space is one of the visual indicators of a successful 5S event. The available floor space was measured.

3.2.3. Inventory

Inventory (parts ready to be assembled) in the assembly area, This measure was monitored along with units produced on 6 particular day. A ratio between the inventory and the number of units produced in the particular day was calculated.

4. Results and Discussion

4.1. Safety Climate

Based on t-test, the p-value of the total and individual scores of the safety cli-

mate (SCAT Tool) for the two groups was calculated as shown in the Table 4. The total scores indicated a significant difference between the two groups. Furthermore, the results pointed that communication was the only item which realized an insignificant level among other safety climate tools. The justification return that in fact, 5S event wasn't directly influence on communication as it relied on personal safety perception than management interaction. On beside that the results defined that involvement was the most affected while the supportive environment was the lowest.

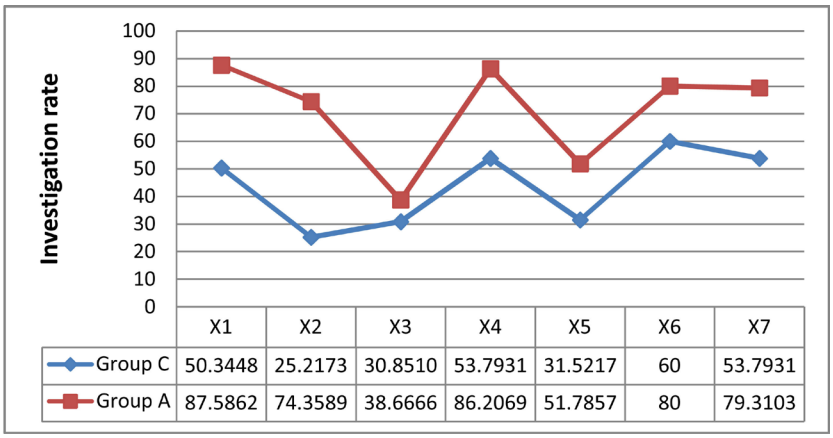
In order to demonstrate the impact of the 5S system on safety climate of assembly workers in each group, the investigation rate of the SCAT items for every topic was calculated and presented in a line chart as follows.

4.1.1. Management Commitment

As shown in (Figure 2) management commitment of safety is more effective at group (A) than group (C). This could be attributed to the strict management

Table 4. Paired t-test result of the safety climate dimensions.

(SCAT) Dimensions	Group C		Group A		P Value
	SD	Mean	SD	Mean	
Management Commitment	2.312953	21.27586	1.863574	22.51724	0.022159922
Communication	1.784581	14.55172	1.162849	15.06897	0.161872768
Priority of Safety	1.378941	22.48276	1.901516	21.48276	0.024655982
Supportive Environment	1.645265	17.27586	1.162849	18.06897	0.049151554
Involvement	0.976321	8.896552	0.939028	9.896552	0.000387826
Personal Priorities and Need for Safety	1.536902	16.82759	1.472239	17.89655	0.011217272
Personal Appreciation of Risk	1.323341	12.41379	1.212618	11.44828	0.015112675
Work Environment	1.038662	18.31034	0.902924	17.62069	0.017204833
Total	4.101243	132.0345	3.654743	134	0.048481282



Source Own Study.

Figure 2. Investigation of management commitment items in each group.

standards which were set up as a part of 5S standardize phase to emphasize improving work area and eliminating hazards which lead to reduce production time.

In addition, the result presented that although the group (A) act decisively and quickly to correct safety problems, the corrective actions are always taken when management is told about unsafe practices. Furthermore, the result revealed a contradictory situation at group (C) where, in spite of interesting in safety, management acts only after accidents have occurred. This concludes that management commitment to safety climate at Egyptian garment enterprises require a supporter system such as monitoring or alarming systems to detect the safety hazards and assigned a proper solution as fast as it can.

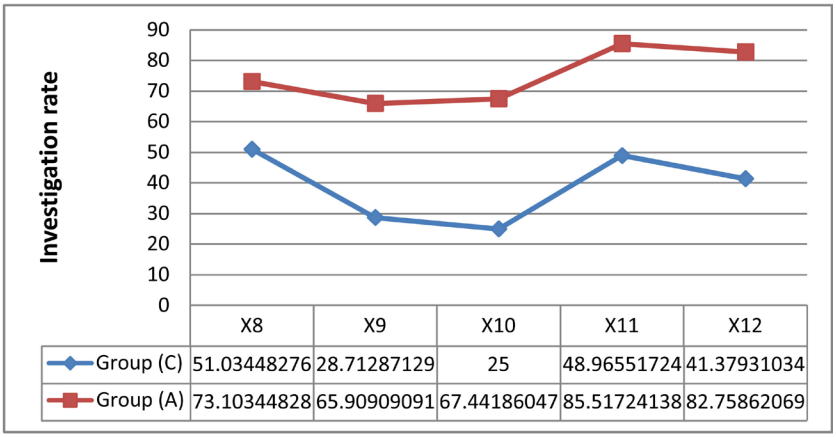
4.1.2. Communication

The result in a Figure 3 reflects the influence of 5S implementation on the communication topic of safety climate, where the group (A) (more 5S applicable) achieving a higher implementation than the group (C) (less 5S applicable). The explanation related to 5S philosophy which powers employees' involvement and enhances their responsibility toward work improvements

Moreover, the results demonstrated that the highest communication policy at the group (A) traced to a continuous attention about safety information, while at the group (C) linked to approach an open door policy on safety issues. In the same vein the result clarified that the lowest policy at the two groups returned to the praise for working safety, which refer that sensitivity of safety issue may be decreased if the administration didn't innovate a new procedures to empower and encourage labors.

4.1.3. Priority of Safety

Figure 4 presents a magnitude effect of 5S event on the priority of safety, where the group (A) are more considering to priority of safety than group (C). In addition, the results stated that although the group (A) following safety rules carefully & regarding safety as important to production, some safety rules and procedures



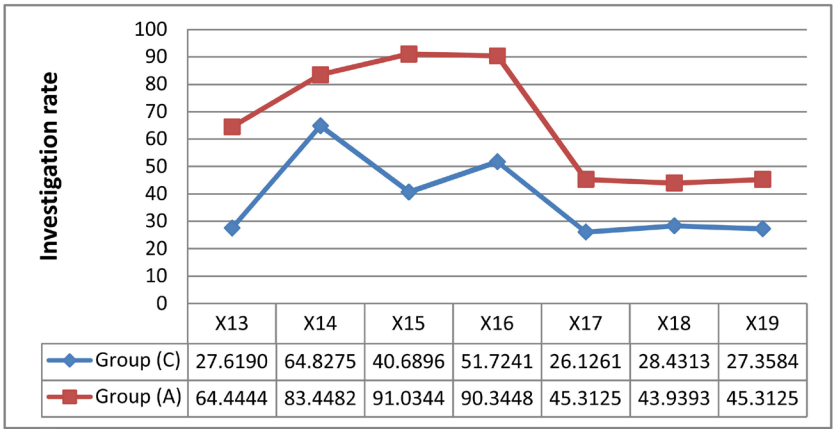
Source: Own Study.

Figure 3. Investigation of communication items in each group.

need to be developed in order to support occupational safety with respect to productivity. On the other hand, the result illustrated that while, the management of group (C) clearly considers the safety of employees of great importance, sometimes its depart from safety requirements for production's sake indicating to necessary for carrying out more training and engagements.

4.1.4. Supportive Environment

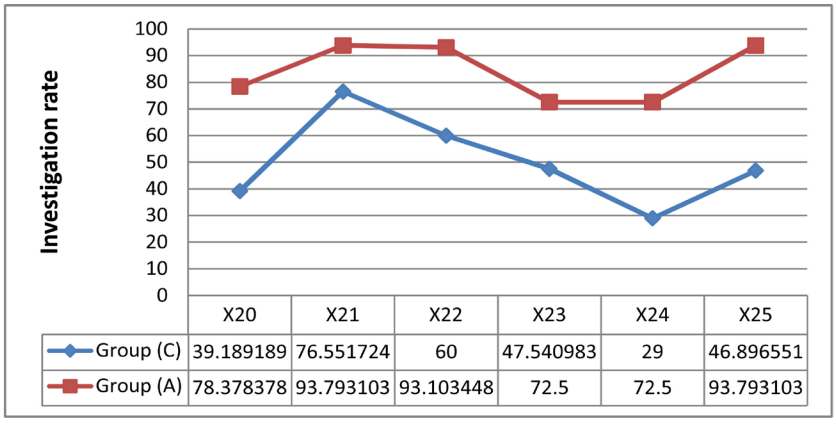
The Scores in Figure 5 identify that group (A) conducts more concentrations on three topics to improve the environment of safety. 1) Cooperation on how to work safely, 2) encouraging to report unsafe conditions and 3) safety responsibility. While on Group (C) the main item associated to interact employees for safety work. On the other way, the result presented that the lowest item at the two groups related to using a no-blame approach to persuade people acting unsafely that their behavior is inappropriate which spotted to the possibility of decreasing on the supportive environment of safety with time. Generally, the chart in Figure 4 demonstrates that the supportive environment of safety climate on a group (A) is more investigated than group (C).



	X13	X14	X15	X16	X17	X18	X19
Group (C)	27.6190	64.8275	40.6896	51.7241	26.1261	28.4313	27.3584
Group (A)	64.4444	83.4482	91.0344	90.3448	45.3125	43.9393	45.3125

Source: Own Study.

Figure 4. Investigation of priority items in each group.



	X20	X21	X22	X23	X24	X25
Group (C)	39.189189	76.551724	60	47.540983	29	46.896551
Group (A)	78.378378	93.793103	93.103448	72.5	72.5	93.793103

Source: Own Study.

Figure 5. Investigation of supportive environment items in each group.

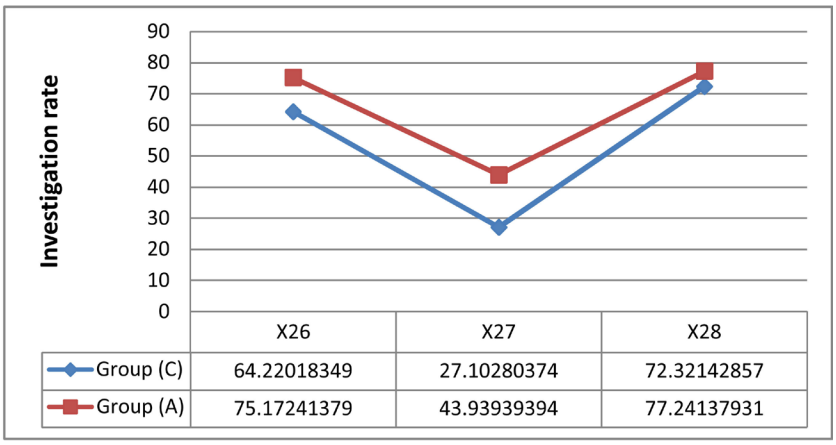
4.1.5. Involvement

Relying on the findings at Figure 6, group (A) accomplishes a higher execution of involvement than group (C) which refers to a significant effect of 5S methodology on administration visions. At the same time, the results refer to a contradictory situation at the two groups as however involving employees with safety issues attained the highest rating, the joining in the ongoing review achieved the lowest, indicating to the necessity of building a strategy that increases the effectiveness of staff's involvement in safety climate to ensure sustainability.

4.1.6. Personal Priorities & Needs

The impact of 5S methodology on personal priorities and needs for safety is presented in Figure 7 where the results stated that the personal priorities of safety are more increasing at the group (A) than group (C). Besides that, the results pointed that understanding the safety rules for the job are the most varied between the two groups.

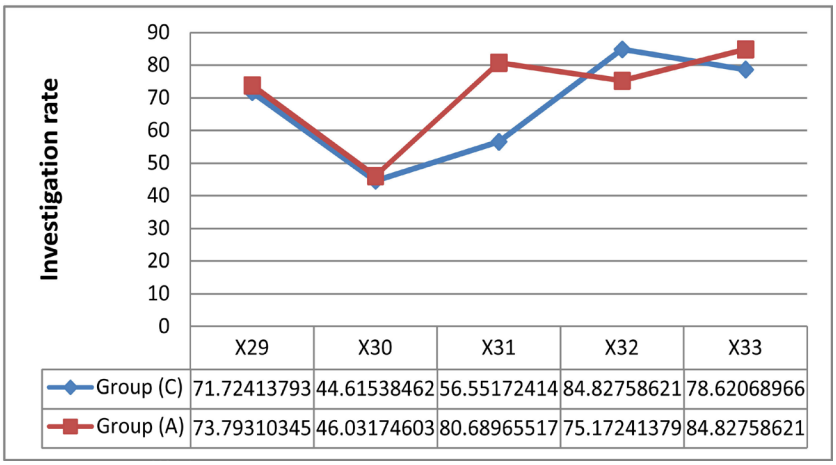
Moreover, the results clarified that in spite of decreasing on personal priorities



	X26	X27	X28
Group (C)	64.22018349	27.10280374	72.32142857
Group (A)	75.17241379	43.93939394	77.24137931

Source: Own Study.

Figure 6. Investigation of involvement items in each group.



	X29	X30	X31	X32	X33
Group (C)	71.72413793	44.61538462	56.55172414	84.82758621	78.62068966
Group (A)	73.79310345	46.03174603	80.68965517	75.17241379	84.82758621

Source: Own Study.

Figure 7. Investigation of personal priorities and needs items in each group.

and needs for safety at the group (C), employees are more considering to emphasis on safety than other group reflecting the potential of improvement can be in sample manner.

4.1.7. Personal Appreciation of Risk

Figure 8 demonstrates the line chart for personal appreciation of risk. The results declared the magnitude of 5S event in appreciation of risk where the group (A) achieved a higher scores (meaning a lower risk and more safety implementation) than group (B).

Furthermore, the scores showed that workers at the two groups were rarely worried about being injured on the job, but at the same time they sure it's only a matter of time before involved in an accident, which identifies that sustaining 5S practices need to be developed in a following manner:

1) Training should occur on a regular basis from top management to the labor force.

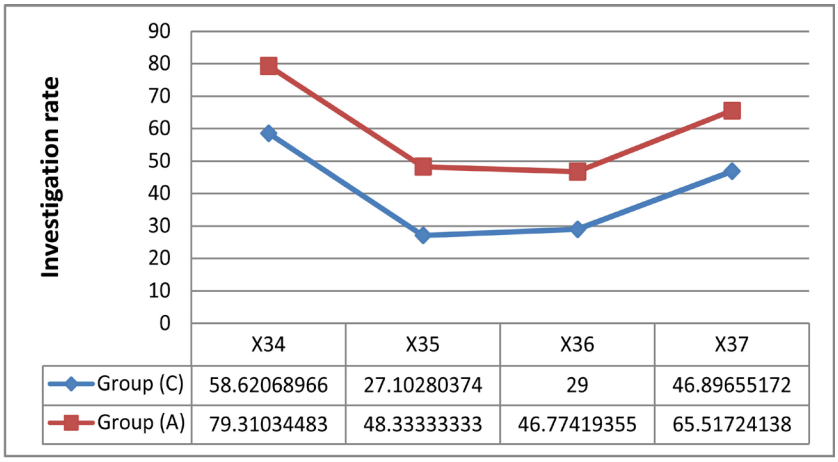
2) Equipment & tools should be placed on their allocated point and the pieces of the garment should be maintained in the defined area.

3) All procedures should be updated and adhered to on a daily basis.

4) An evaluation should be performed and kept as required for assessment at the end of each month.

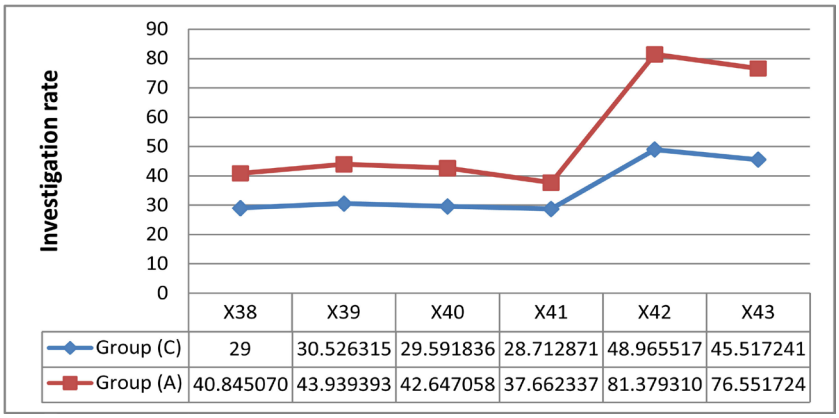
4.1.8. Work Environment

The effectiveness of 5S principles on the work environment of safety climate was demonstrated in Figure 9, where the group (A) realized a higher implementation than group (C). In addition the results present that the highest investigation of the two groups returned to availability of enough people to get the job done safely while the lowest investigation connected to time reduction to get the job done safely which refer that standardize of time at Egyptian garment enterprises require more development and practicing in order to achieve target production in a safe manner.



Source: Own Study.

Figure 8. Investigation of personal appreciation of risk items in each group.



	X38	X39	X40	X41	X42	X43
Group (C)	29	30.526315	29.591836	28.712871	48.965517	45.517241
Group (A)	40.845070	43.939393	42.647058	37.662337	81.379310	76.551724

Source: Own Study.

Figure 9. Investigation of work environment items in each group.

4.2. Productivity Measures

4.2.1. Cycle Time

The cycle time was defined as the time it takes the assembly worker to assemble a unit (T-shirt) with all the parts. All the parts were already available on the workstation. The average of total time for group (C) to assemble T-shirt parts was 46 minutes approximately (2.3) minutes per unit, as measured with 12 samples while The total time for group (A) to assemble was 42 minutes ~ (2.1) minutes/unit which is a 8.69% decrease. This showed that the 5S event effectively reduced the cycle time of assembling a unit

4.2.2. Floor Space Utilization

The floor space utilized by the assembly for material storage, handling and aisles were measured. In group (C) the average of the total area utilized by the assembly was 41.5 m^2 while the floor space utilized by the group (A) assembly was 52.7 m^2, which is a 26.9 % increase. The explanation related to 5S attribution to remove unnecessary equipment and parts which took up space in the workplace (the first stage: sort) and standardize of a pull concept as opposed to the traditional push concept which resulted in moving the units to the next step immediately after completion. So, the units were never placed on the floor, which freed up space (The fourth stage: standardization).

4.2.3. Inventory Held up

A ratio (inventory held up to the number of units finished) was calculated. Lower ratio equaled to better inventory management. A mean ratio of group (C) was 6.38 per unit ($146,866 in inventory held up to 23 units finished), while the mean ratio of group (A) was 3.74 per unit ($119,833 in inventory held up to 32 units finished). The ratio decreased by 41.3%. This showed that the 5S event effectively reduced the inventory held up in the assembly area.

5. Conclusions

5S has a significant impact on 7 of 8 topics of safety climate. Communication was

the only item which realized insignificant level among other safety climate tools.

The results stated that the management commitment & the priority of safety climate at Egyptian garment firms needs to be developed. As well as, increasing usage of a no-blame approach to persuade people acting safely to support work environment shall be magnified. Contradictory situations were observed, referring to the necessity for more empowering, practicing and accountability. The results assigned that productivity measures influenced by 5S event, where the production cycle time decreased, the utilized floor space increased and the inventory reduced.

On the other hand, the results presented the strong positive relation between 5S polices and safety climate where group A (the most applicable to 5S event) achieved a higher investigation of the SCAT items than group C (the lowest applicable) which provide evidence of lean affecting occupational safety.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix: Safety Climate Assessment Toolkit

Q No.	Question	Strongly disagree	disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Management Commitment						
X1	Management acts decisively when a safety concern is raised					
X2	Management acts only after accidents have occurred					
X3	Corrective actions are always taken when management is told about unsafe practices					
X4	In my workplace management acts quickly to correct safety problems					
X5	In my workplace management turn a blind eye to safety issues					
X6	In my workplace managers/supervisors show interest in my safety					
X7	Managers and supervisors express concern if safety procedures are not adhered to					
Communication						
X8	Management operates an open door policy on safety issues					
X9	My supervisor does not always inform me of current concerns and issues					
X10	I do not receive praise for working safely					
X11	Safety information is always brought to my attention by my line manager/supervisor					
X12	There is good communication here about safety issues which affect me					
Priority of Safety						
X13	I believe that safety issues are not assigned a high priority					
X14	Management clearly considers the safety of employees of great importance					
X15	Safety rules and procedures are carefully followed					
X16	Management considers safety to be equally as important as production Safety Rules and Procedures					
X17	Sometimes it is necessary to depart from safety requirements for production's sake					
X18	Some health and safety rules and procedures are not really practical					
X19	Some safety rules and procedures do not need to be followed to get the job done safely					
Supportive Environment						
X20	Employees are not encouraged to raise safety concerns					
X21	Co-workers often give tips to each other on how to work safely					
X22	I am strongly encouraged to report unsafe conditions					
X23	When people ignore safety procedures here, I feel it is none of my business					
X24	A no-blame approach is used to persuade people acting unsafely that their behavior is inappropriate					
X25	I can influence health and safety performance here					
Involvement						
X26	I am involved in informing management of important safety issues					

Continued

X27	I am never involved in the ongoing review of safety
X28	I am involved with safety issues at work
Personal Priorities and Need for Safety	
X29	Safety is the number one priority in my mind when completing a job
X30	Personally, I feel that safety issues are not the most important aspect of my job
X31	I understand the safety rules for my job
X32	It is important to me that there is a continuing emphasis on safety
X33	A safe place to work has a lot of personal meaning to me
Personal Appreciation of Risk	
X34	I am rarely worried about being injured on the job
X35	In my workplace the chances of being involved in an accident are large
X36	I am sure it is only a matter of time before I am involved in an accident
X37	I am clear about what my responsibilities are for health and safety
Work Environment	
X38	I cannot always get the equipment I need to do the job safely
X39	Operational targets often conflict with safety measures
X40	Sometimes conditions here hinder my ability to work safely
X41	Sometimes I am not given enough time to get the job done safely
X42	There are always enough people available to get the job done safely
X43	This is a safer place to work than other companies I have worked for