

Workers' Perspectives: Emotional Consequences of Lean Manufacturing Change Using Six Sigma in the Bangladesh Textile Sector

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Abstract

Lean Six Sigma is widely recognized for driving industrial efficiency, yet its effectiveness ultimately relies on an often-overlooked element: the human mind. In labor intensive sectors, such as Bangladesh's textile industry, where continuous process improvement is essential for global competitiveness, implementation efforts frequently encounter socio-technical resistance rooted in low literacy, limited conceptual understanding, and operational constraints. This study investigates these human-centered challenges by examining workers' emotional and perceptual responses before, during, and after the introduction of Six Sigma practices. A qualitative research design was employed, using transcribed and coded individual interviews as the primary data source. The findings reveal a clear progression of

emotional stages. At the outset, workers demonstrated strong denial, confusion, and resistance, driven by uncertainty and difficulty grasping Six Sigma's technical and graphical concepts. Their educational limitations and the absence of an established culture of continuous improvement further amplified these negative reactions. As the implementation matured, workers gradually transitioned toward acceptance. In the final stage, they recognized the value of the improvements, reporting enhanced productivity, greater clarity in tasks, and more efficient workflow execution. Acceptance emerged only when workers observed concrete, comprehensible results, underscoring the critical role of communication, simplified explanations, and leadership support. This study provides practical guidance for organizations seeking to implement Lean Six Sigma in low-literacy, labor-intensive environments and lays the groundwork for future broader quantitative validation across diverse industrial settings.

Keywords

Lean manufacturing, Six Sigma, Workers' perspective, Productivity, Textile Industry

1. Introduction

Lean Six Sigma is a powerful philosophy for driving industrial efficiency, but its true potential depends on an often-overlooked factor: the human mind. In the Bangladeshi textile sector, continuous process improvement is mandatory for global survival, but its implementation encounters significant socio-technical resistance rooted in low literacy and operational constraints. Lean manufacturing (LM) has become essential for improving production processes and creating value through waste elimination since its first appearance in the "Toyota miracle" (Singh, 2011). Two main pillars of lean manufacturing are 'Jidoka' and 'JIT', with the goal to produce higher quality at the lowest possible cost (Dennis, 2007). The Six Sigma method is a project-driven management approach to improve the organization's products, services and processes by continually reducing defects (Kwak & Anbari, 2006). It was first used by the Motorola company. The best use is to combine lean and Six Sigma together (Atmaca & Girenes, 2013). Six Sigma enhances work ability and focuses on quality more than speed, reducing wastages (Atmaca & Girenes, 2013). However, most workers in the garments industry are deprived of formal education and are not familiar with these improvement techniques. They fail to acknowledge the benefits, and this lack of comprehension means that the psychological well-being of workers following lean principles is often neglected (Antony et al., 2022). Their perception or acceptance towards LM techniques like Six Sigma does not support the improvement process (Antony et al., 2022).

The objective of this paper is to review and examine the evolution and challenges considering mental stress on workers due to Six Sigma practices and identify the key factors influencing workers to lower their interest in Six Sigma method. The novelty of this work lies in being the first to examine workers' emotional responses to Six Sigma in a developing nation where 73% have only primary education and revealing that low literacy is the root cause of resistance rather than just a lack of training (Castillo et al., 2018; Ali et al., 2020). This research is crucial because it provides actionable guidance for organizational leaders in Bangladesh on adapting communication and training for low-educated workforces to anticipate and prevent negative reactions. Future research should build on these findings by conducting quantitative validation studies across multiple organizations and developing economies to test the generalizability of the emotional stage progression identified here.

1.1 Objectives

The main target of this research is to examine worker behavior and acceptance when applying LM techniques such as Six Sigma, and identify the underlying causes of behavioral changes. The specific objectives are:

1. Identify factors that influence the denial of Bangladeshi workers to adopt new LM techniques
2. Determine factors influencing workers to lose job satisfaction
3. Examine the organizational role in worker acceptance
4. Analyze the stages of acceptance of new LM processes by workers over time

2. Literature Review

Six Sigma focuses on quality more than speed using DMAIC (Define, Measure, Analyze, Improve, Control) and DMADV (Define, Measure, Analyze, Design, Verify) methodologies (Atmaca & Girenes, 2013). It improves cycle time by eliminating non-value-adding steps and has been considered a strategic approach to improve business profitability through statistical and non-statistical tools (Antony & Banuelas, 2002). Product quality is a basic guarantee of manufacturing companies and an important point in survival (Syafwiratama et al., 2017). Six Sigma is a

systematic method for process improvement that uses a statistical approach in reducing defect rates defined by customers (Syafwiratama et al., 2017).

2.1 Six Sigma Process in Textile Sector

Few examples of textile lean Six Sigma (LSS) successes exist in literature. (Adikorley et al., 2017) addressed dyeing and finishing problems in a large Indian company manufacturing terry towel, specifically shade mismatches when fabrics were dyed. Using LSS methodology, several factors (water, temperature, dye stuff, and time) were manipulated to find optimum settings to obtain the right shade in one dyeing process, yielding 4% improvement.

Implementing Six Sigma in Bangladesh's textile sector is challenging due to busy schedules and work-related stress. Employees in the garments sector, the largest contributor (18%) of GDP in Bangladesh, are under stress due to physical, psychological and financial imbalances (Steinisch et al., 2013). A survey of 869 garment factories in two Dhaka sub-districts collected data from 284 respondents. Factor analysis identified job uncertainty, long working hours, less family time, lack of administrative support and work overload as significantly related to job stress (Sogra, 2017). Workers are bound to work 12 hours minimum, with some working 14-15 hours (Warrick-Schkolnik, 2020). This stress prevents workers from adapting to new techniques like Six Sigma.

Lack of formal education is a vital reason for workers' denial of Six Sigma in Bangladesh. 73% of workers only passed primary education, 19% high school, and only 8% crossed HSC (Bhuiyan, 2012). Workers struggle to understand the objectives and benefits of Six Sigma. Six Sigma emphasizes technical improvements but not effects on human resources (Dennis, 2007), causing workers to accept it as an extra burden (Rampasso et al., 2017).

2.2 Lean Manufacturing and Six Sigma from Workers' Perspective

LM eliminates waste while maximizing customer value. Three types of waste exist: (1) Muda (non-value-adding), (2) Mura (operational unevenness) and (3) Muri (overburdened conditions) (Suárez Barraza & Ramis-Pujol, 2010). Successful implementation depends upon employees who play a crucial role (Tortorella et al., 2018). Six Sigma is a simple but powerful technique that enables organizations to see value-adding processes (Longoni & Cagliano, 2016). For successful implementation, workers must be committed and involved (Costa Maia et al., 2017).

One barrier to LM implementation is employee resistance to adopting new methods due to competence in old methods and insufficient leadership support or training. Studies on LM often exclude human resource management practices from research. Recent studies show human resource management in LM processes can significantly moderate effects on worker health (Stimec, 2020). Knowing how LM techniques affect workers remains critical (Longoni et al., 2013). Longitudinal research is needed to address LM effects from inception to completion, as changes are generally perceived negatively by workers initially (Kiefer, 2005).

Studies are required that enhance soft lean practices (training, educating, promoting human resources) rather than hard lean practices (methods, systems, procedures), especially considering 80% of effort needed to implement LM relates to changing workers' practices and behaviors (Mann, 2009).

2.3 Negative Perspective of Change: Six Emotional Stages

LM improvements sometimes generate uncertainty and concern amongst workers (Rafferty et al., 2013). Changes cause individuals to transition through six stages: Denial/Anger, Bargaining, Depression, Revising, Deserting and Acceptance (Castillo et al., 2018). In Denial/Anger, workers experience stress and uncertainty, preferring to remain as they are. In Bargaining, workers seek positive elements and try to convince each other everything will be fine. In Depression, workers lose hope of adapting, feeling empty and unmotivated. In Revising, workers question whether to leave the organization. In Desertion, workers leave because they cannot accept changes. In Acceptance, workers accept changes honestly without anger or resentment (Castillo et al., 2018).

These emotional stages originate from workers' perception of organizational justice, particularly procedural and informational justice (Castillo et al., 2018; Tyler & Lind, 2002). Procedural justice is the equity individuals perceive in organizational processes. Informational justice refers to perception about information the organization provides about change processes (Imberman, 2009).

2.4 Resistance and Coping Strategies of Change

Workers' perception of change provides tools to predict reactions (Fugate & Kinicki, 2008), which are coping strategies that generate counterproductive workplace behaviors (Bowling & Eschleman, 2010). (Lazarus, 2006) presented three adaptive coping processes: strategies leading to harmony with change (troubleshooting, information searching, impotence, escape); strategies using social resources (self-sufficiency, support searching, delegation, isolation); and strategies coordinating desires toward change (accommodation, bargaining, presentation, opposition). Workers' reactions can lead change to fail (Amarantou et al., 2018). This research addresses LM study through Six Sigma focused solely on workers' perspective, leaving technical aspects in the background.

3. Methods

Figure 1 shows the method.



Figure 1. Methodology flowchart of the research study

3.1 Approach and Research Design

This research relied on case studies as a theory generator (Ketokivi & Choi, 2014). Through case study analysis, it is possible to derive theory not identified in literature. The specific analysis of LM improvements through Six Sigma implications represented a novelty in literature. Qualitative research was chosen, as the literature shows that when insufficient evidence exists in a field of study, prior exploratory analysis is required through inductive data (Silverman, 2017). The research team remained outside the case study and did not actively participate, only witnessing events and collecting empirical data for subsequent analysis (Ketokivi & Choi, 2014).

3.2 Case Study Company

The company where the case study was conducted is AMAN KNITTINGS LTD. in Hemayetpur, Savar, Dhaka. AMAN has been in the sector for over 25 years and is dedicated to the manufacture of products for export. The company has a total of 7000 workers. The linking team of sample production is made up of a total of 20 workers. This team is preferred to be called as "Green Team". AMAN has detected that one of the busiest production lines is the one producing the product called A, production times are very long and customer orders are not met on time. Aiming to avoid possible commercial consequences with the product A, a process of continuous improvement began in January that consisted of three steps:

- (1) Analysis of the “product A” in the manufacturing process using Six Sigma
- (2) Implementation of improvements after analyzing DMAIC process
- (3) Conducting final Six Sigma process considering improvements made.

In each phase, the research team for this study, external to the company, conducted interviews with the workers involved to learn how they experienced the changes. It should be noted that AMAN had been introducing the LEAN philosophy in the company for six months prior to the project described in this research, through various training sessions for its staff, but no implementation had been conducted until then.

3.3 Sample

The sample selected for the study was all manufacturing workers of the Green Team: a total of 20 workers. The reason is that, although not everyone works at the same time on the line, they are multipurpose positions and the changes that are made will affect everyone due to their weekly rotation. The sample used was sufficient for the study context considering the criteria established which indicates that for qualitative case-based research, the valid sample size should be between 15 and 30 interviews. On the other hand, other references (Saunders et al., 2018) suggest that the sample size is sufficient when data saturation is reached. In our case, saturation was reached at 15 interviews, by which time 100% of the codes used in this research had been created.

3.4 Data Collection Method

The two measurable variables collected were Average Lead Time (in minutes) for producing a single quantity of product A, and the Worker Satisfactory Percentage. To conduct the interviews, we used the semi-structured interview format because, although a previously defined script is used, it is not necessary to follow the defined sequence to formulate the questions, and new questions can be added depending on the interviewee (Rubin & Rubin, 2011). To develop the script, we followed the findings of the literature in this context and especially focused on (Castillo, 2022) who analysed how organizational changes affect workers. We did not stipulate any time limit for the interviews, and they were conducted in a sample linking section within the company itself. The interviews were conducted by the researchers (individuals external to the company) so that there was no hierarchical intimidation when answering the questions. All interviews were recorded with the workers' consent in order to facilitate their subsequent transcription and analysis.

Google documents were used to record the statements of the workers with a specific set of questions. These questions were asked in two stages: (1) a short time after the implementation of Six Sigma, and (2) after a period of six months of implementing Six Sigma. Individual transcribed and coded interviews were the primary method of data collection for qualitative analysis.

The sample data were collected in three steps:

(1st step) Prior to implementation of Six Sigma: Data were collected from the industry chart boards in two measurable variables: (a) Average lead time in the sample linking section, and (b) Worker satisfactory level percentage in sample linking section (Measured by a company named ELEVATE through labour-link system).

(2nd step) After the implementation of Six Sigma: Data was measured by the research team by evaluating the average time of workers on production of product A. The satisfactory index percentage was collected from the survey of the company through labour-link. Each worker's performance was tracked over three consecutive working days. Individual production times were recorded and normal time was calculated as the arithmetic mean of the three-day measurements.

Average time = Total time needed for the workers for producing a single quantity of A / 20

(3rd step) After six months of implementing Six Sigma: Data was collected by the research team after a time period of six months. The average time was again measured by the research team. The satisfactory level data was also collected from the factory survey charts.

4. Results and Discussion

4.1 Numerical Results

Data collected from factory premises prior to implementing Six Sigma improvements on the Green Team showed the initial baseline metrics

- Average time needed to produce A: 43 minutes
- Satisfactory level percentage: 85

Data was collected immediately after the implementation of the Six Sigma process. The satisfactory index percentage was collected from the company survey through the labor-link system, showing 70% satisfaction. Each worker's performance was tracked over three consecutive working days. Individual production times were recorded and normal time was calculated as the arithmetic mean of the three-day measurements. Table 1 shows the normal time of workers just after implementing Six Sigma.

Table 1: Normal Time of Workers Just After Implementing Six Sigma

Worker ID	Day-1	Day-2	Day-3	Normal Time
A	43.2	46.7	47	45.6
B	44	46.7	49	46.5
C	44.2	46.9	47	46
D	43	48	45	45.3
E	45	46	47	46
F	46	45.5	46	45.83
G	41	45	44	43.33
H	43	45	49	45.6
I	46.5	47	48	47.16
J	41.5	42	43	42.16
K	42	43	44	43
L	49	46.5	50	48.5
M	41	42.5	40	41.16
N	46	49	47	47.33
O	47	46	48	47
P	43	45	47	45
Q	47	45.5	46	46.16
R	46	44	49.9	46.63
S	47.5	48	47	47.5
T	43.5	44	45	44.16

- Satisfactory level percentage: 70%
- Average time = $(890.92/20) = 44.5$ minutes

Data was again collected by the research team after a period of six months following the implementation. Table 2 shows the normal time of workers after 6 months of implementing Six Sigma.

Table 2: Normal Time of Workers After 6 months of Implementing Six Sigma

Worker ID	Day-1	Day-2	Day-3	Normal Time
A	42	44	45	43.6
B	43	44	49	45.33
C	45	46.5	48	46.5
D	40	43	45	42.6
E	46	48	47	47
F	44	46.5	47.5	46
G	44	48	45	45.6
H	44	42	41	42.3
I	42	43.5	44	43.16
J	40	42.5	43	41.8
K	41	40	44	41.16
L	43	44.5	45	44.16
M	44	42.5	44	43.5
N	44	45	46	45
O	43	41	46	43.33
P	45	44	49	46
Q	40	42.5	44	42.16
R	46	44	49.9	46.63
S	43	44.5	45	44.16
T	43.2	42	40	41.73

- Satisfactory level percentage: 80%
- Average time: $(870.28/20) = 43.5$ minutes

The initial implementation of Six Sigma improvements on the Green Team led to a temporary decline in performance metrics, followed by a recovery after a stabilization period (Table 3).

Table 3: Comparative performance metrics across implementation phases

Metric	Prior Implementation	Right after Implementation	Six months after Implementation
Average Time (minute)	43.0	44.5	43.5
Satisfactory Rate (%)	85%	70%	80%

The average time index of Green Team shows that after implementation, production time increased to 44.5 minutes but improved to 43.5 minutes after six months. The worker satisfactory rate dropped significantly from 85% immediately after implementation, then recovered to 80% after six months. This drop in both productivity and satisfaction created an "exhausting situation among the workers" and aligns with the literature showing that changes are initially perceived negatively (Kiefer, 2005). After six months, the Average Time dropped to 43.5 minutes, indicating a process improvement of 1 minute over the baseline, and the satisfactory rate recovered to 80%, confirming that workers began to see the effective results.

4.2 Graphical Results

The qualitative data from the personal interviews, presented graphically, illustrates the distinct emotional phases experienced by the workers, validating the stages of organizational change (Figure 2).

Initial Phase (Denial and Exhaustion):

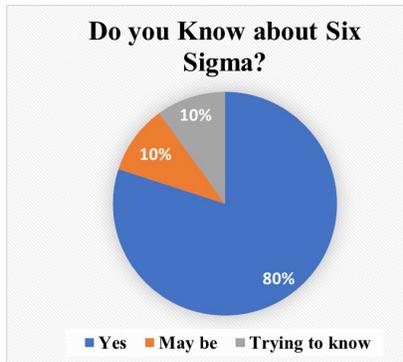


Figure 2(A)



Figure 2(B)

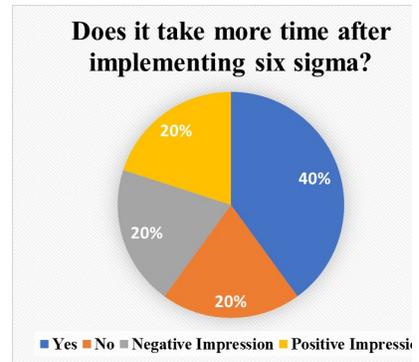
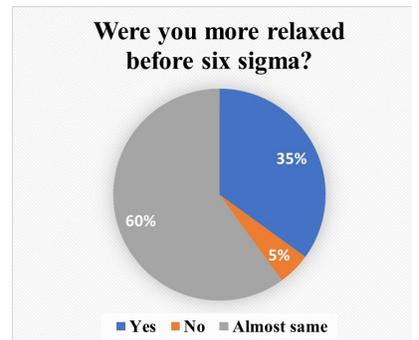
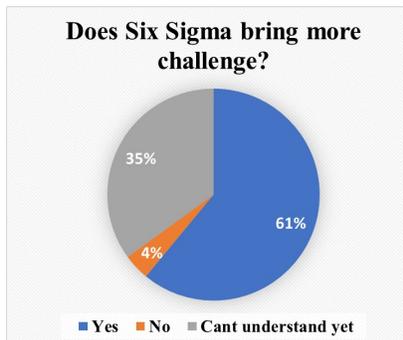


Figure 2(C)



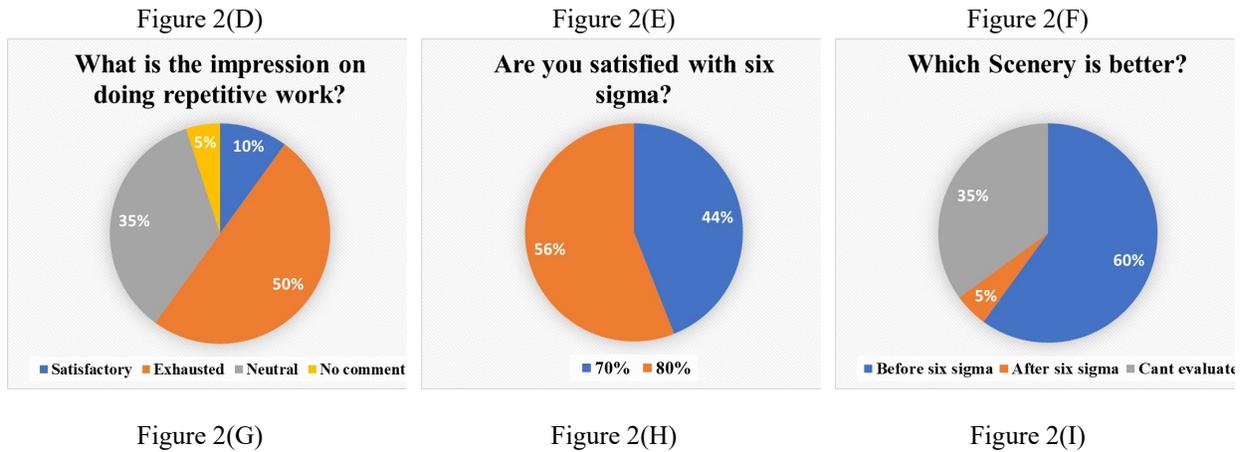


Figure 2. Representation of the personal interviews right after implementing Six Sigma

Right after the implementation, the majority of workers (80%) knew about Six Sigma conceptually, with 10% maybe knowing and 10% trying to know (Figure 2A). However, this awareness did not translate into understanding or acceptance. When asked whether Six Sigma was improving their productivity, 70% of the workforce reported they "Can't understand yet," with only 15% confirming improvement and 15% denying any improvement, indicating high uncertainty (Figure 2B). This shows that workers were confused about the whole process and could not comprehend what was happening with their productivity.

Regarding time perception, 40% of workers felt that it took more time after implementing Six Sigma, and another 20% had negative impressions, while only 20% had positive impressions and 20% said no (Figure 2C). This perception that work became slower created frustration. Workers also felt that Six Sigma brought more challenges to their work, with 61% agreeing it brought more challenges (Figure 2D). This perception of increased difficulty contributed to their resistance. Although 90% of workers received training about Six Sigma, with only 10% not interested (Figure 2E), the training did not help them understand the practical application, which shows that standard training approaches were insufficient for low-educated workers.

When asked if they were more relaxed before Six Sigma implementation, 35% agreed they were more relaxed before, 60% said it was almost the same, and only 5% disagreed (Figure 2F). This indicates that Six Sigma did not significantly increase stress for most workers, but a notable portion felt less relaxed. The emotional impact was more clearly visible in workers' impressions of doing repetitive work: a dominant 50% expressed feeling exhausted by the repetitive work, 35% felt neutral, 10% felt satisfactory, and 5% had no comments (Figure 2G). This confirms the emotional stage of Denial/Anger (Castillo et al., 2018) and the presence of stress (Lazarus, 2006). Workers' satisfaction levels with Six Sigma were generally low, with 44% reporting 70% satisfaction, 56% reporting 80% satisfaction (Figure 2H). This shows moderate to low satisfaction immediately after implementation.

The negative sentiment was reflected in the overall assessment, where 60% indicated the scenery "Before Six Sigma" was better, 35% couldn't evaluate, and only 5% preferred the scenario after Six Sigma (Figure 2I). The worker satisfaction rate was lowered down from 85% to 70%. Even the average time was much greater than the prior situation. This created a depressing and exhausting situation among the workers.

Stabilization Phase (Acceptance and Improvement):

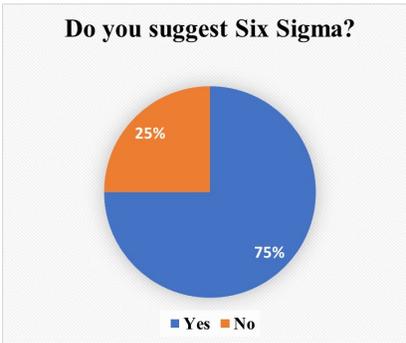


Figure 3(A)



Figure 3(B)

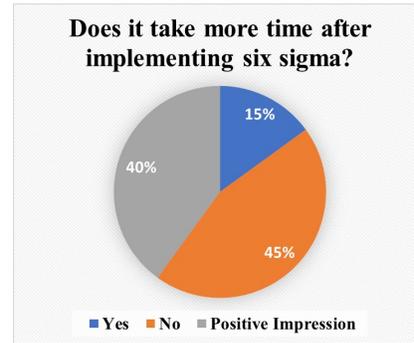


Figure 3(C)

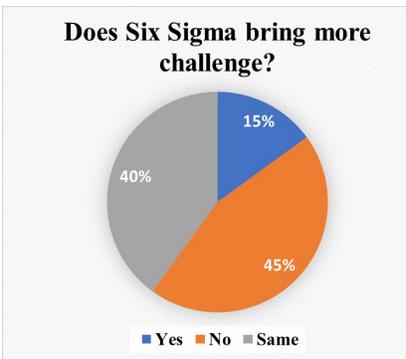


Figure 3(D)



Figure 3(E)

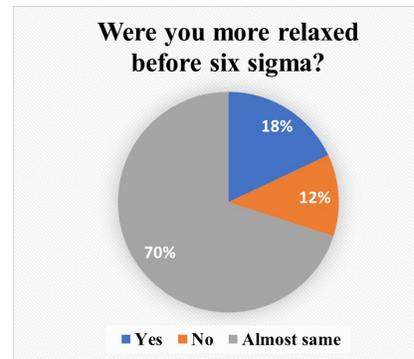


Figure 3(F)

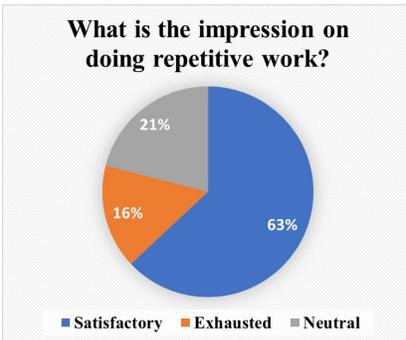


Figure 3(G)

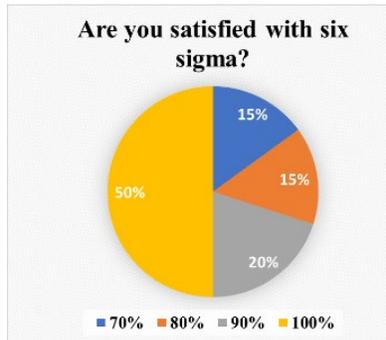


Figure 3(H)

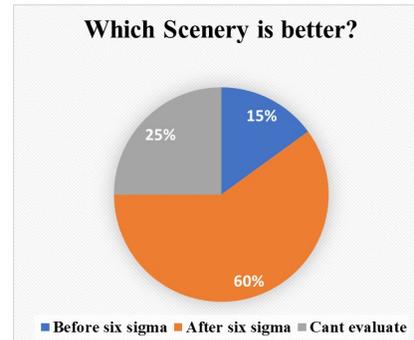


Figure 3(I)

Figure 3. Representation of the personal interviews after six months of implementing Six Sigma

Data collected six months later demonstrated a clear transition into the Acceptance stage. When asked if they would suggest Six Sigma to others, 75% of workers said yes and only 25% said no (Figure 3A). This dramatic shift in willingness to recommend shows genuine acceptance. The belief in the process reversed, with 85% of workers confirming that Six Sigma was improving their productivity, while only 5% said no and 10% still couldn't understand (Figure 3B). This is a remarkable transformation from the initial 70% who couldn't understand.

Workers' time perception also improved significantly. When asked if it took more time after implementing Six Sigma, 45% said no, 40% had positive impressions, and only 15% said yes (Figure 3C). This shows that workers now realized

the process was actually faster. Regarding challenges, 45% of workers now felt Six Sigma did not bring more challenges, 40% felt it was the same as before, and only 15% still felt it brought challenges (Figure 3D). This is a major shift from the initial 61% who felt it brought more challenges. Workers also reported that the training about Six Sigma was sufficient (Figure 3E). This improvement in perceived training adequacy came from seeing actual results and understanding the purpose.

When asked if they were more relaxed before Six Sigma, 70% now said it was almost the same, 18% agreed they were more relaxed before, and 12% disagreed -meaning they felt more relaxed now (Figure 3F). This shows that stress levels normalized over time. Emotionally, a majority of 63% reported feeling satisfactory with repetitive work, with the exhausted figure dropping dramatically to 16%, and 21% feeling neutral (Figure 3G). This positive shift indicated an increase in worker satisfaction. These results also agreed with the existing literature in which it has been concluded that a pleasant work environment favours the satisfaction of workers and increases productivity (Bangwal & Tiwari, 2019).

Workers' satisfaction levels with Six Sigma improved substantially, with 50% now reporting 100% satisfaction, 20% reporting 90% satisfaction, 15% reporting 80% satisfaction, and 15% reporting 70% satisfaction (Figure 3H). This is a dramatic improvement from the initial phase where no one reported 90% or 100% satisfaction. Ultimately, 60% of workers stated the scenery "after" Six Sigma was better, 25% couldn't evaluate, and only 15% still preferred before Six Sigma (Figure 3I), demonstrating acceptance and commitment to the correctly implemented changes (Castillo et al., 2018). This is a complete reversal from the initial phase where 60% preferred before Six Sigma. Through this emotional stage of Acceptance, our results showed that there was an increase in collaboration amongst workers, commitment to the project and conviction that the changes that have been made had been the correct ones. This conviction had a strong relationship with each individual's job performance.

4.3 Proposed Improvements

The primary cause for the negative perception and resistance during the initial and mid-phases of the Six Sigma process was a profound difficulty in comprehension. Workers reported that the graphical representation and technical concepts prevented them from understanding the proposed changes on their own, which made them distrustful (Ali et al., 2020). This lack of understanding directly influenced negative perceptions of informational (Sharma & Kumra, 2020) and procedural justice (Tschantz, 2019).

The two main underlying causes identified were:

- **Complexity of the Method:** Six Sigma utilizes graphs, figures, and technical concepts that triggered a lack of understanding due to the complexity of the system (Ali et al., 2020).
- **Educational Level of Workers:** The fact that almost 73% of the workers only had primary level schooling (Bhuiyan, 2012) complicated the understanding of core concepts such as cycle time and material flow, acting as a human-centric barrier to implementation (Riddell & Song, 2012).

Therefore, to address this, organizational leaders implementing Six Sigma should:

- **Adapt Communication:** Managers should utilize Six Sigma analysis tools internally, but when explaining improvements to workers, the communication should be adapted without using technical elements or language that could make it difficult for them to understand (Ali et al., 2020).
- **Foster Understanding:** This adaptive strategy, aimed at fostering communication and understanding, is necessary to reduce the initial negative emotional impact on workers.

4.4 Validation

The study's findings are validated by their strong internal consistency and correlation with established psychological and change management models (Castillo et al., 2018).

- **Emotional Stages Validation:** The quantifiable transition from a low satisfactory rate of 70% and increased time of 44.5 minutes post-implementation (Denial/Anger) to an improved time of 43.5 minutes and a satisfactory rate of 80% after six months, directly validates the progression toward the Acceptance stage (Castillo et al., 2018).
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- **Root Cause Validation:** The finding that the technical complexity, exacerbated by the workers' educational background, was the root cause of initial resistance validates the central proposition of the study. This unique contribution identifies that technical concepts and graphical representations of Six Sigma constitute a barrier to implementation in contexts with lower worker education (Riddell & Song, 2012), demonstrating that resistance to change before and during the implementation process only improved when results began to be seen (Ali et al., 2020).

5. Conclusion

This study fills a critical gap by analyzing how the implementation of LM techniques affects the workers by exploring the emotional perceptions of workers during Six Sigma process. The study employed inductive analysis at AMAN Knittings Ltd., where interviews were conducted with 20 workers in three phases. The results showed that workers progressed through three emotional stages and eventually Six sigma increased their productivity and work performance. The main cause for the negative perception was the difficulty in understanding Six Sigma graphical representation due to its technical complexity and workers' educational level. It is recommended for organizational leaders to adapt Six Sigma representations without using technical elements or language that could make it difficult for workers to understand.

A major limitation of this study is the similar educational backgrounds and the conclusions are based on a single case study. The organization also lacked a pre-existing continuous improvement culture.

For future research directions, it is recommended to conduct broader quantitative studies that measure the impact on workers before, during, and after LM implementation, using larger sample sizes. Future studies should also examine workers with diverse educational backgrounds, as well as companies operating in more automated production environments, to determine whether emotional responses differ. In addition, other LM techniques such as JIT, Kaizen and Kanban should be investigated to understand their specific emotional effects on workers. Future research should further explore organizations with an established culture of continuous improvement. Finally, studies should analyze the implications that arise when only certain groups of workers are affected

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Biographies

Mohammad Fazle Rabbe is a dynamic textile professional with a strong background in product development and merchandising within the fashion and apparel industry. He currently serves as Executive, Merchandising (Product Development) at The Source Expert (Medici Fashion DMCC BD Liaison Office) since 2024, where he specializes in developing knit, woven, and flat-knit products. With over four years of hands-on experience in product development, Fazle Rabbe Mahfuz has consistently delivered innovative and practical solutions, leading material and component development while ensuring strict adherence to fabric quality, lab-dips, wash effects, print processes, and cost optimization. He collaborates closely with global teams across design, sourcing, sustainability, and quality to meet buyer requirements, while maintaining updated material pricing and analyzing sourcing risks. Prior to his current role, he served as Junior Executive (2022–2024) and Management Trainee Officer (2021–2022) at Aman Knittings Ltd., where he oversaw supplier quality requirements, executed new orders, managed deliveries, supported quality issue resolution, and contributed to product development for kids' and men's wear, including child safety compliance. He holds a B.Sc. in Textile Engineering from Bangladesh University of Textiles (BUTEX) and combines technical expertise with strong skills in communication, leadership, critical thinking, and adaptability, making him a versatile professional in textile product innovation.

Soudho Shikhar Roy is a fourth-year undergraduate student at the Bangladesh University of Textiles, where he ranks 1st in merit in the Department of Apparel Engineering. His academic and research work focuses on multifunctional and nanoparticle-enhanced textile materials, particularly in areas such as surface functionalization, UV protection, antimicrobial performance, and advanced finishing. In addition to material science, he has strong interests in smart textiles, technical and special-purpose apparel, consumer behavior, and Lean Manufacturing (LM) techniques, with a particular emphasis on how LM-driven process optimization can improve productivity, reduce waste, and enhance operational efficiency across the apparel industry. His academic orientation merges material innovation with industry-focused improvements, enabling a holistic understanding of both product and process development. He intends to pursue a Ph.D. in functional textiles and wearable systems, with long-term goals of contributing to advanced textile materials research and fostering innovation within the global materials and apparel ecosystem.

Md. Tanvir Ahmed is a dedicated Sustainability and Circular Economy expert committed to driving resource efficiency across traditional industries. Currently contributing his expertise at Aurajoki Oy, a metal coating company in Turku, Finland, Tanvir is focused on integrating sustainable practices into industrial operations. His academic foundation is robust, holding an MSc in Circular Economy and Risk Management from Tampere University of Applied Sciences, Finland, and actively pursuing a second MSc in Sustainability: resource, chemistry and materials from Leuphana University, Germany. With a background beginning in Textile Engineering Management (BSc, Bangladesh University of Textiles) and nearly one year of practical experience in textile manufacturing in Bangladesh, Tanvir uniquely bridges the foundational knowledge of materials and production with advanced concepts of waste reduction and closed-loop systems. He aims to leverage cutting-edge research to transform industrial processes into environmentally and economically viable models.

Bebe Fatema Bristy has completed her B.Sc. in Textile Engineering from the Bangladesh University of Textiles in the Department of Apparel Engineering, under the Faculty of Textile Fashion Design and Apparel Engineering. She

secured the 1st merit position with the record of achieving highest grade till now in her department. This academic excellence earned her the *Dean's Award*, the *UGC Medha Britti Award*, and a nomination for the prestigious *Prime Minister Gold Medal*, the nation's highest honor for a student. Following graduation, she embarked on her professional journey as an academician, beginning as a Lecturer in the Department of Textile Engineering at "University of Scholars" and currently serving at "BGMEA University of Fashion & Technology", one of Bangladesh's leading private universities specializing in textiles and apparel education. Her research work spans diverse areas of textile materials, with a consistent focus on innovation, sustainability, and advancing the field through both academic inquiry and practical application. Her published research projects include the development of self-cleaning defense textile material surfaces for military personnel, nanotechnology, graphene-based wearable sensors, smart textiles, LCA of textile materials, and apparel production systems. Her current works under review include studies on superhydrophobic surface functionalization of textiles, graphene-based multifunctional protective clothing, and using textile wastewater as a feedstock for renewable hydrogen production. Looking to the future, she has ambitious plans to continue her academic journey while contributing to the materials industry in meaningful ways with her unwavering commitment to research and impressive track record.