Proceedings of the 2016 International Conference on Industrial Engineering and Operations Management
Detroit, Michigan, USA, September 23-25, 2016

Critical Success Factors for Successful Implementation of Six Sigma in Pakistani Industries

Zahid Abbass Shah
Institute of Quality and Technology Management, University of the Punjab, New Campus, Lahore, 54590, Pakistan.
zahid.iqtm@pu.edu.pk

Asfa Muhammad Din
The University of Lahore, 1-km Raiwind Road,
Lahore, Pakistan.
asfa.engineer@gmail.com

Abstract

Six Sigma has found a widespread application in a variety of organizations. However, its successful implementation depends on some critical factors. Identification and analysis of these factors is crucial in order to obtain desired results. The purpose of this study was to identify the factors critical to successful implementation of Six Sigma in a country where it is still new. Critical success factors were identified from literature and then a questionnaire was prepared. This questionnaire was sent to different industries. The data obtained through filled questionnaires from 55 respondents were analyzed. It is concluded from the results that some of the tools are being used extensively while some others are used rarely. The most critical barriers to implementation are difficulty to encourage suppliers for Six Sigma, not gaining financial outcomes from Six Sigma projects, and difficulty in making it a part of business strategy. Top management commitment, business strategy, cultural change, organizational infrastructure, and customers are more valuable for large manufacturing organizations. While small scale organizations give priority to accountability and project prioritization, tracking, and review. For the service sector training of employees and involvement of suppliers are the most important factors for successful implementation of Six Sigma.

Keywords: Six Sigma, Critical Success Factors, Six Sigma Implementation, Pakistan

1. Introduction

Continuous process improvement is a major requirement of any industry in order to improve productivity, customer satisfaction, and profitability. There have been a number of approaches of quality management that have proved to bring process improvements – Six Sigma is relatively a newer approach that has gained acceptance among practitioners in a number of industries (Wang, 2010). Apparently it may seem similar to the older quality improvement approaches, but it is different in many ways. It focuses on breakthrough improvements. Some organizations that adopted it claim that it helped them transform their business. (Schroeder et al., 2007).

Six Sigma is a systematic process improvement methodology focusing on removing the causes of variation or defects from manufacturing and service processes. Nowadays Six Sigma is mostly implemented as a quality improvement method in industries. However, many organizations fail to implement it properly and suffer a great financial loss. There are a number of challenges and myths that cause failure to its implementation: Six Sigma is all about statistics, it can be applied in manufacturing organizations and large organizations only, it requires strong infrastructure with massive investment etc. (Kumar et al. 2008). For the successful implementation in industries there are some factors which are critical to the success. Identification of Critical Success factors (CSFs) is a very important step to demystify the myths of Six Sigma implementation as well as ensure its sustainability. This is particularly important for developing countries where industries are always under pressure to survive.

The industrial sector is the 2nd largest sector for economic development in Pakistan. It is lacking the adoption of modern tools and techniques of process improvement and excellence. Six Sigma is an example. The purpose of current

study was to analyze the level of understanding regarding this tool and the factors considered by Pakistani industries while going for Six Sigma projects.

2. Literature Review

In 1920's the word "sigma" was used as a unit to measure product quality variations. Motorola was the initial developer of "Six Sigma" and evolved it into a comprehensive management tool. Its main focus is to identify quality related problems – be it defects, failures, or mistakes – and either eliminate or reduce them. The ultimate goal is to enhance the performance of the system and increase the satisfaction of customers (Kumar et al., 2008). It has been applied by a variety of industries and has resulted in huge monetary savings (Abdolshah et al., 2009).

Brady et al. (2006) define Six Sigma as

"An organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates".

Apart from being a statistical basis of measurement, Six Sigma is also a *philosophy* and a *goal*: a *vision*, and a *metric* (Chaudhary, 2012). The primary framework to implement Six Sigma projects is DMAIC: define, measure, analyze, improve, and control. DMADV approach i.e. define, measure, analyze, design, and verify is used when organization is going to develop a new product or service (Hung and Sung, 2011).

Tools and techniques that are used as a part of a DMAIC project include supplier-input-process-output-customer (SIPOC) diagram, quality function deployment (QFD), process capability analysis, benchmarking, failure mode and effects analysis (FMEA), Pareto analysis, design of experiments, and cause and effect diagram (Gygi et al. 2005, Heizer and Render, 2011).

Six Sigma can bring many benefits. Motorola achieved the defect rate of 3.4 parts per million within five years. Subsequently, a number of well-known organizations reported the successful implementation of this tool and obtained substantial benefits. They include Sony, Honda, ABB, Lockheed Martin, Texas Instrument, Bombardier, Polaroid, Caterpillar, Johnson & Johnson, American Express, Ford, Lear Corporation, and Solectron (Klefsjo et al., 2001). DuPont reported $1.6 billion cost saving by implementing 3000 Six Sigma projects with the help of 10,000 Master Black Belts (Pokharkar et al., 2010). Some examples of cost savings from Six Sigma are shown in Table 1. However, implementing Six Sigma does not bring just financial benefits; there are numerous other benefits too. They include improved product and service performance, organizational growth, reduced cycle time, customer satisfaction, and creation of well-supported structure.

Table 1. Cost Savings from Six Sigma (Knowles, 2012)

Motorola	$414 billions
GE (General Electric)	$2billions
Honey Well	$ 600 to 700 billions
Dow Chemical	$2.2 Billion
Texas instruments	$ 600 million
Johnson and Johnson	$ 500 million

Initially developed for manufacturing sector, Six Sigma is now adopted both by manufacturing and service organizations irrespective of their size. Mount Carmel Health System in Columbus gained $3.1 million financial return by implementing Six Sigma (Sehwail & DeYong, 2003). Bank of America is pioneer in implementing Six Sigma in financial services sector. Customer satisfaction increased by 10 % and customer complaints decreased by 24% after bank implemented a number of Six Sigma projects in different sectors (Kwak & Anbari, 2006).

However, there is other side of the picture as well. Many companies believe that Six Sigma is a management fad; it will sweep the world as a fashion for some time and then will disappear. Common myths and misunderstandings about Six Sigma (Kumar et al., 2008, Pokharkar et al., 2010) are that it

- is an expensive tool; requires massive investment without real cost savings.

- focuses on various statistical tools and training and ignores human factors e.g. culture change, commitment of employees and top management.
- is only for manufacturing organizations.
- is re-packaged for TQM.
- is magic pill to fix problems with little efforts.

Hence, a lack of pre-requisite knowledge of what Six Sigma is and how it should be applied to a particular business can result in drastic failures (Moosa & Sajid, 2010). Identification of these Critical Success factors (CSFs) is a very important step to demystify the myths of Six Sigma implementation as well as ensure its sustainability. Researchers (Moosa & Sajid, 2010, Desai et al., 2012, Sharma and Chetiya, 2012, Hilton and Sohal, 2012) have reported a number of factors, including:

Top Management Commitment

Without continuous involvement of top management, true benefits of Six Sigma methodology cannot be achieved. Top management has to ensure that Six Sigma is a best strategy for process improvement and it must be sustained before, during and after implementation of process.

Organizational Infrastructure

Six Sigma introduction and development program in any organization require completely dedicated employee, cross-functional teams and facilitative leadership behavior. Six Sigma's infrastructure means commitment of staff, top management, money, time, and resources.

Culture Change

Six Sigma requires change in thinking (mindset of people) to get changed (better) performance. Effective communication system is required to motivate individuals and educate seniors, employees and customers. Communication plan must include the importance of Six Sigma, and how it can be applied to the organization in focus. To get results from implementation projects include practical feedback from employee about successes and obstacles of projects. Culture change mean Six Sigma must be part of everyday life.

Education and Training

Education and training of the employees of a company is the one of the most important aspects to effectively implement any quality tool. People are the key to change in any organization. If they are not willing to do work with you as part of implementation strategy, no measurable benefits can be achieved. When an organization trains and educates people and realize the employee that they are part of organization, Six Sigma or any other tool can give the best measurable results.

Understanding Six Sigma Methodology

If organizations want to implement Six Sigma successfully tools and techniques must be clear and understood by its employees. Well planned implementation training tools are well understood. Accurate data is required for proper analysis of work and to support decision of management. Metrics can be used for defects rate and cost of poor Quality etc.

Linking Six Sigma to Suppliers

Strong involvement of suppliers in Six Sigma program can be beneficial for the organization to bring supplier closer to customer to improve the quality of product/process. Six Sigma methodology explains that to reduce variability in your process, organizations must have few suppliers with high performance capability analysis. If you want to be a Six Sigma company then you should involve supply chain management in the implementation strategy.

Linking Six Sigma to Customers

Customers are the priority of every organization. If organizations (manufacturing or services) want to improve the Quality of process then they must understand the customer requirements. To identify core business activities and customer needs are critical to quality characteristics. Quality function deployment can be used to translate customer needs into core business activities of the organization.

Linking Six Sigma to Business Strategy

Six Sigma cannot be considered as standalone activity. For the successful implementation it must be combined with business strategy. Six Sigma is just not only usage of tools with complicated statistics. It is methodology to make profit for business while attacking on the process variability issues like high scrap rate, rework/rejection rate and low productivity. When Six Sigma implementation is in process then projects of Six Sigma and objective achievement plans (business strategy) must be aligned.

Communication

For the successful implementation of any system, communication between organizational activities is basic important tool. If communication system is not proper then management may not be successful to implement any Quality affecting strategy like Six Sigma etc. Communication can be in form of discussion with employee, seminars, Six Sigma benefits awareness session and workshops etc.

Project Selection

A good project selection is very important, because well done is always better than well said. Project selection is the first step to move towards well done. Project selection must be always aligned with business strategy. Poorly selected projects are great cause of frustration. Good project must be challenging.

Project Tracking and Review

Project tracking and review must be conducted on scheduled basis to meet the various milestones. Most of the projects fail to complete because poor determination of meeting rules and responsibilities related the deadlines of project. Project status and progress must be reported to the top management.

Accountability

Accountability and financial gain of Six Sigma project is the most interesting aspect for the owner of organization. But accountability is only possible when projects are properly implemented, tracked and completed.

The purpose of this research was to analyze which of the factors is given more importance in implementing Six Sigma in Pakistan – a country where this methodology is still novice.

3. Methodology

The research was conducted using questionnaire survey. It is the best method to collect data in an economical way from a large number of respondents in a short period of time (Singh, 2007). The questionnaire was distributed among 200 industries and got response from 55; a response ratio of 27.5%. Criteria for selecting an organization was that either

- It must have implemented Six Sigma, or
- It must be in a process of implementing it, or
- It must have plans to implement it.

Organizations were classified into 3 categories: Large Manufacturing (29), Small Manufacturing (15) and Service Sector (11).

To check the reliability of a scale Cronbach's alpha is commonly used. Reliability can take value from 0 to 1. For the questionnaire used in this study, Cronbach's α was found to be 0.869 (Table 2), that shows acceptable reliability.

Table 2. Cronbach's α for questionnaire used in this study

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.869	0.879	12

4. Results

The following sub-sections discuss the results of this survey.

4.1 Six Sigma Trained Personnel

It was recorded that 60.0% of small manufacturing, 75.9% of large manufacturing, and 90.9% of service industries had quality control departments. The numbers of persons with Six Sigma training were distributed among three industry types with similar ratios (Table 3). All three had majority (around 55%) with 3-5 trained persons and no significant difference was observed with p-value of 0.588.

Table 3. Distribution of the companies by the number of Six Sigma trained persons

Number of persons with Six Sigma training	Company_Type					
	Small Manufacturing		Large Manufacturing		Service	
	n	%	n	%	n	%
Nill	4	26.7	1	3.4	1	9.1
Only one	0	0.0	1	3.4	0	0.0
3 - 5	8	53.3	16	55.2	6	54.5
5 - 10	2	13.3	7	24.1	2	18.2
More than 10	1	6.7	2	6.9	1	9.1
Many	0	0.0	2	6.9	1	9.1
Total	15	100.0	29	100.0	11	100.0

4.2 Use of Tools and Techniques

Cause and effects analysis, process mapping, benchmarking, process capability analysis, and Pareto analysis were found to be among the most widely used tools in Six Sigma projects. The tools that have less than 40% usage are considered as less commonly used tools (Table 4).

Table 4. Usage of Six Sigma Related tools in Pakistani industries

Most Commonly Used tools & Techniques	**Least Commonly Used tools & techniques**
Cause and Effect Analysis (76%)	Failure Mode Effect Analysis (34%)
Process Mapping (52%)	Quality Function Deployment (30%)
Benchmarking (50%)	Supplier Input Process Output Customer (27%)
Pareto Analysis (47%)	Poka Yoke (21%)
Process Capability Analysis (47%)	Design of experiments (18%)

4.3 Analysis of Critical Factors

The rotated component matrix showing the correlations between the variable and the factor is given in Table 5. Factor loadings of 0.50 have been ignored to remove low correlations that are assumed to be insignificant.

Table 5. Rotated component matrix[a]

	Component		
	1	2	3
Business Strategy	.823		
Linking Six Sigma to Customer	.771		
Top Management Commitment	.770		
Organization is effectively measuring the financial impact of Six Sigma projects.		.831	
Project prioritization and review		.704	
Project Tracking and		.613	
Cultural Change	.536	.601	
Selection of Right project		.540	
Organizational Infrastructure	.524	.534	
Organization encourages suppliers to involve in the Six Sigma initiatives.			.794
Training & Education			.756
Communication			
Extraction Method: Principal Component Analysis. **Rotation Method**: Varimax with Kaiser Normalization.			
a. Rotation converged in 6 iterations.			

Based on these correlations, the 12 factors have been reduced to three underlying components (Table 6).

Table 6. Summary of factor analysis of critical success factors

Component	% of variance	Factors Involved in order of Importance	Factor loading
Component_1	43.76	Clear business strategy, Encouraging customers to participate in training, Top management support and concern Cultural changes Organizational Infrastructure	0.823 0.771 0.770 0.536 0.524
Component_2	10.78	Accountability Project prioritization Project tracking & Review Facility Cultural Changes Project Selection Understanding of Six Sigma methodology	0.831 0.704 0.613 0.601 0.540 0.534
Component_3	8.89	Supplies Encouragement (suppliers) Training (TRAINING)	0.794 0.756

Component_1: Clear business strategy, Encouraging customers to participate in training, Top management support and concern, Cultural changes and organizational infrastructure – this factor accounts for 43.76 percent of the variation in the data.

Component_2: Accountability, Project prioritization, Project tracking, Cultural changes, Project selection and understanding of Six Sigma methodology – this factor accounts for 10.78 percent of the total variation.

Component_3: Supplier encouragement and Training– This factor accounts for 8.89 percent of the total variation in the data.

A summary of the three factors along with percentage variance and factor loading value of each component are shown in Table 6.

Comparison of Components by Company Types:

The average score for component_1 was highest for the large manufacturing companies, component_2 for small manufacturing and the component_3 had highest average score for services sector (Table 7).

Table 7. Descriptive measures for the three components for company types

	Company Type								
	Small Manufacturing			**Large Manufacturing**			**Service**		
	Component_1	Component_2	Component_3	Component_1	Component_2	Component_3	Component_1	Component_2	Component_3
Mean	12.89	12.76	4.75	13.14	12.67	4.83	12.56	11.71	5.28
SD	2.31	2.95	1.43	2.14	2.68	1.34	2.32	1.77	1.51
Min	8.21	8.86	2.31	7.62	6.80	2.34	8.98	8.25	3.06
Max	16.60	18.58	6.99	17.12	18.50	7.75	16.06	13.43	7.75

On comparison among companies with various number of trained belts average scores were found significantly different for all three components with p-values 0.005, 0.003 and 0.017 respectively (Table 8).

Table 8. Comparison of average values for the three components among the companies with different number of trained Six Sigma belt

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Component_1	Between Groups	59.371	4	14.843	4.228	0.005
	Within Groups	172.034	49	3.511		
	Total	231.405	53			
Component_2	Between Groups	97.066	4	24.266	4.673	0.003
	Within Groups	254.441	49	5.193		
	Total	351.507	53			
Component_3	Between Groups	22.104	4	5.526	3.342	0.017
	Within Groups	81.016	49	1.653		
	Total	103.120	53			

Pairwise comparison between companies provide with information that for component_1, the companies with 5 – 10 trained belts had significantly higher average score than the companies with 3 -5 trained belts with p-value 0.002. This group also had differences of similar magnitude from companies with nil, more than 10 and many trained belts but were not significant with p-values 0.101, 0.141 and 0.181 respectively. For component_2 the companies with 5 – 10 trained belts had significantly high average score than companies with nil, with 3 – 5 and with more than 10 belts with p-values 0.035, 0.003 and 0.028 respectively. For component_3 the only significant difference was between the companies with 3 - 5 trained belts and more than 10 belts with p-value 0.039 (Table 9).

Table 9. Pair wise comparison of average values for the three components among the companies with different number of trained Six Sigma belt

Dependent Variable	(I) Trained Six Sigma belts	(J) Trained Six Sigma belts	Mean Difference (I-J)	Std. Error	Sig.
Component_1	Nill	3 - 5	0.22	0.84	0.999
		5 - 10	-2.40	0.95	0.101
		More than 10	0.19	1.21	1.000
		Many	0.34	1.32	0.999
	3 - 5	5 - 10	-2.62*	0.66	0.002
		More than 10	-0.03	1.00	1.000
		Many	0.12	1.13	1.000
	5 - 10	More than 10	2.59	1.09	0.141
		Many	2.74	1.22	0.181
	More than 10	Many	0.15	1.43	1.000
Component_2	Nill	3 - 5	-0.36	1.02	0.996
		5 - 10	-3.44*	1.16	0.035
		More than 10	0.64	1.47	0.992
		Many	-1.91	1.61	0.761
	3 - 5	5 - 10	-3.08*	0.80	0.003
		More than 10	1.00	1.21	0.921
		Many	-1.54	1.38	0.796
	5 - 10	More than 10	4.08*	1.33	0.028
		Many	1.54	1.48	0.837
	More than 10	Many	-2.55	1.74	0.591
Component_3	Nill	3 - 5	-0.72	0.58	0.716
		5 - 10	-1.60	0.65	0.118
		More than 10	0.60	0.83	0.951
		Many	0.38	0.91	0.993
	3 - 5	5 - 10	-0.88	0.45	0.311
		More than 10	1.32	0.68	0.316
		Many	1.11	0.78	0.615
	5 - 10	More than 10	2.20*	0.75	0.039
		Many	1.99	0.84	0.140
	More than 10	Many	-0.21	0.98	1.000

5. Discussion

It is concluded from results that large manufacturing organization have more black belts as compared to small manufacturing. Service sector has departmental managers and small manufacturing companies have more executives as compared to large manufacturing.

In large manufacturing people are more experienced rather than in small manufacturing. But small and large manufacturing have same results with respect to experience working with Six Sigma. In service sector of Pakistan, although implementation of Six Sigma is less, but where people are implementing it in service sector they are having most experienced persons and have completed more projects.

Training programs are is a best way to involve people of organization in effective way. Experienced practitioners' guidance and mentoring can help organization gain desired results on projects. Involve all stakeholders especially suppliers and customers to achieve best outcomes.

It is concluded from the results that tools and techniques for Six Sigma implementation are used effectively by Pakistani organization at any phase of process whether it is manufacturing or service.

It is also concluded from the results that organizations focus on business strategy/objectives and training of their employees for best outcomes of the results.

Analysis of factors has been done for large and small manufacturing and service sector.

Applying Principle Component Analysis the most rating factors are encouragement of suppliers, financial outcomes, and business strategy. This shows that most critical barriers are difficulty to encourage supplier for Six Sigma, not to gain financial outcomes from Six Sigma projects, and difficulty to make it part of business strategy. Culture change, top management commitment, customer involvement, and project prioritization and review are critical if organization is committed to achieve its business goals. Training of the employees, project selection, and communication are also important factors to layout the activities of Six Sigma projects.

A total of 12 factors have been divided into 3 components. Component 1 having top management commitment, business strategy, cultural change, organizational infrastructure, and customers are more valuable for large manufacturing organization. Small organizations give highest score to component 2 because such types of organizations project implementation, monitoring, and evaluation are central for successful implementation of Six Sigma methodology. Component 3 has highest average score for service sector because training of employees and involvement of suppliers is very important. It is impossible to effectively deliver service without these two stakeholders.

It is concluded from results that component 2 is very important for completion of projects. Component 2 having proper project selection, project tracking and review, cultural change, understanding of Six Sigma tools, and accountability are important factors for successful implementation of Six Sigma methodology. Organizations who have completed 3-5 projects on Six Sigma rate component 2 with high score. Organization irrespective of their size and working have same components for successful implementation of Six Sigma.

Cultural change is a common factor in both component 1 and 2. As six sigma is a breakthrough methodology, it requires a thorough change in the way an organization works. It is not merely applying a set of tools. When people will be ready to accept change training them will become easier. It will also facilitate communication among different entities of the organization. However, to bring such change involvement of all parties be it top management, suppliers, or customers is a must.

Future research can focus sector-specific implementation and critical success factors of Six Sigma. It should also focus on hurdles that organizations face to implement it.

6. References

Abdolshah, M., Ismail, M. Y., Yusuff, R. M., and Hong, T. S., Overcoming the challenges of implementing Six Sigma in service industries, *International Conference on Information Management and Engineering*, *IEEE Xplore*, pp. 191-195, 2009.

Brady, J. E. and Allen, T. T., Six Sigma literature: A review and agenda for future research, *Quality & Reliability Engineering International*, vol. 22, no. 3, pp. 335–367, 2006.

Chaudhari, P. P., Key for implementation of Six Sigma in Indian industries, *Journal of Information and Operations Management*, vol. 3, no.1, pp. 203-205, 2012.

Desai, D. A., Antony, J., and Patel, M. B., An assessment of the critical success factors for Six Sigma implementation in Indian industries, *International Journal of Productivity and Performance Management*, vol. 61, no. 4, pp. 426 – 444, 2012.

Gygi, C., DeCarlo, N., and Williams, B., *Six Sigma for Dummies*, Wiley Publishing, Inc., New Jersey, 2005.

Hilton, R. J., Sohal A., A conceptual model for the successful deployment of Lean Six Sigma, *International Journal of Quality & Reliability Management*, vol. 29, no. 1, pp.54-70, 2012.

Hung, H. C. and Sung, M. H., Applying Six Sigma to manufacturing processes in the food industry to reduce quality cost, *Scientific Research and Essays*, vol. 6, no. 3, pp. 580-591, 2011.

Heizer, J. and Render, B., *Operations Management*, 10th Edition, Pearson Education Inc., Prentice Hall, New Jersey, 2011.

Knowles, G., *Profit from Six Sigma: A Guide to Principles and Practice for Business Benefit*, Graeme Knowles and Ventus Publishing ApS, 2012.

Kwak, Y. H. and Anbari, F. T., Benefits, obstacles, and future of Six Sigma approach, *Technovation*, vol. 26, no. 5-6, pp. 708-715, 2006.

Kumar, M., Antony, J., Madu, C. N., Montgomery, D. C., and Park, S. H., Common myths of Six Sigma demystified, *International Journal of Quality & Reliability Management*, vol. 25, no. 8, pp. 878 -895, 2008.

Klefsjo, B., Wiklund, H., and Edgeman, R. L., Six Sigma seen as a methodology for total quality management, *Measuring Business Excellence*, vol. 5, no.1, pp. 31-35, 2001.

Moosa, K. and Sajid, A., Critical analysis of Six Sigma implementation, *Total Quality Management and Business Excellence*, vol. 21, no. 7, pp. 745–759, 2010.

Pokharkar, D., Jadhav,V., Gholve, S., and Kadam, V., Six Sigma: Golden Opportunity for Pharmaceutical Industry, *International Journal of PharmTech Research*, vol. 2, no.2, pp. 1160-1164, 2010.

Sehwail, L. and De Yong, C., Six Sigma in health care, *Leadership in Health Services*, vol. 16, no. 4, pp. 1-5, 2003.

Singh, K., *Quantitative Social Research Methods*, Sage Publications Inc., London, 2007.

Schroeder, R.G., Linderman, K., Liedtke, C., and Choo, A.S., Six Sigma: Definition and underlying theory, *Journal of Operations Management*, vol. 26, no. 4, pp. 536–554, 2007.

Sharma, S., and Chetiya, A. R., An analysis of critical success factors for Six Sigma implementation, *Asian Journal on Quality*, vol. 13, no. 3, pp. 294-308, 2012.

Wang, H., A review of Six Sigma approach: methodology, implementation and future research, *IEEE Xplore*, pp. 1-4, 2010, Available: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4680076

Biography

Zahid Shah is a senior lecturer at Institute of Quality and Technology Management, University of the Punjab, Lahore, Pakistan. His areas of teaching and research include operations management, lean manufacturing, production engineering, and human factors engineering. He has worked on several projects related to human factors and production and operations analysis involving local industry, especially textiles and garments, shoe manufacturing, and automotive vendors. Some of these projects have been converted into case studies that are used as basis for class discussion to depict challenges facing the local industry.

Asfa Muhammad Din is lecturer at Mechanical Engineering Department, The University of Lahore. She holds BS and MS degrees in Industrial Engineering and Management. Her areas of interest include workplace design, six sigma, and lean manufacturing.