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Excellence Of The Quality Tools And Their Application: The Quality Professionals' Perspective

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Abstract: Quality tools are the ones that give cutting edge to the process or business. It carries remarkable weightage when it comes to the deliverables. A proper use of quality tool can provide break through improvements in quality, efficiency and the business results. The selection of such tools hence is very important. However, in spite of the importance the tools used may not be on the merit and may just get into place by a single person's opinion or a trend or the thing in vogue or based on what the peers and competitors are using. Some times that tools are used only to show that it is part of their stable. This sorry state of selection is very common and companies end up paying hefty amounts for tool that are not good for them and are just a part of the introduction page of the organization. This paper is based on the study of the tools, their usage and their perceive benefits to assign a number to the tool that will tell the unitality or goodness of the tool for the purpose. There is not recommendation of a single tool for a purpose but it gives you a range of tools and range of alternatives that the user need to select from so that the purpose is met. The paper has two distinct parts, one sharing the name of the tools and their usage so that the user is aware what they are looking at and the other part is about the utility of these tools basically for improving quality of the product or process. Whever rating is done, the assessor needs to be well versed with the entity. Since there are quite a few tools considered here, it becomes very challenging to get right juries or assessors to rate the tools. However, thanks to the development of the Automobile Industry over past 140 odd years, which uses most of the tools under consideration, there are ample number of professionals who authoritatively can comment about the goodness of the tools. For this paper these were the group of elite professionals who were contacted. These are head of the department of quality, holding positions like President, Vice president, Directors, Senior General Mangers and so on. There were other senior professionals like Six Sigma Master Black Belt, Black Belts from reputed agencies like American Society of Quality (ASQ) and likes. most of these professionals were from Automobile OE manufacturers producing Cars, Trucks, Tractors & Farm Equipments, Two wheelers and Engine manufacturers. Based on their experience they rated these tools in 1 to 10 scale, 10 being the ones having most significant effect on quality improvement efforts and 1 being very low effect on quality improvement. The output of the research is in the form of a

number assigned to the tool that tells about how effective this tool is in relation to the efforts to improve quality. Higher the number better the tool for the purpose.

Keyword: Quality, Quality Tool, Quality Tools Implementation, Quality tools' Rating, Parts per PPM

INTRODUCTION

The purpose of this study is to impart knowledge to the quality professionals on the type of quality tools available and being used and which of those are good for their purpose. The user can look at the number assigned and the information provide in the paper to decide which tool would best suit to them.

Quality is used so much so and so vaguely that it becomes a task in itself to define Quality. The terms may not have been used then but essence of the word was present right from the stone age, when the then man would check the sharpness of their spade by feel of a touch. He would smell the bulb dug out from the earth or fruit plucked from the tree to see if it is good for consumption. Those perhaps were the first quality checks that were performed by a human, dating back to 5000 years before Christ's arrival. Though it is so widespread and known from eternity , defining quality is not simple. However as always International Standards Organization (ISO) made this job easy for us. It has defined quality as. "The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs". Keeping its reputation intact, ISO definition is very tough to understand and needs at least one more read through to get real meaning out of it. But experts agree that this is the most complete definition. The simplest definition however comes from the stalwart, Juran in 1950s, who described quality as "Fitness for use". This is so simple that people, but not experts, feel like it's understated. By all means it carries true meaning and other definitions like value for money, reliability, meeting the customer needs are all by some way or other related to these two definitions.

Though the understanding of quality is old, need to improve the quality and benefits of improving quality on other aspects of the business was realized only during the World War II (WWII). The leadership in quality was with Europeans and then with Americans till around 1960s. However, thanks to the request from the US president and General McArther, Deming and later Juran visited Japan and they got closely associated with Japanese Union of Scientists and Engineers (JUSE), bringing in a remarkable shift in the way they look at the quality. The work done by Prof. Ishikawa had already made inroads in to the Japanese industry that became a strong foundation for Deming an Jurant to work upon. In 1970 the equation and balance of quality tilted in favor of Japanese brands and they started ruling the world. Japanese companies made an assault on the worlds largest and richest market, the North America and displaced the American companies from top spots. This not only happened in mechanical industries like automobiles but also got extended to electronics. this was the time when American government and the industry took notice of this shift and put in place a recovery process, making what they call as the new age business model, on which Malcolm Baldridge Quality Award was announced. This was actually an extension of Deming Award released by Japan. The efforts gave a lot of shoots and one such again change the world in the form of Six Sigma, the finest cluster of multiple quality tools.

Quality and Quality tools are related. In each era, if we consider an era to be of 20 years, there was at least one tool or set of tools that has made an impact. These tools obviously continued to exit later, but over the period lost their premium standing. Some of the examples are Ishikawa's basic 7 Q C tools, Companywide Quality Control (CWQC), Six Sigma, Total Quality Management (TQM), that made a noticeable jump in the quality levels.

As the time progressed the tools changed. However it is very interesting to know if the Ishikawa's work on 7 QC Tools was not prevailing, could Juran and Deming have made so much difference. How much do the Ishikawa's tools find interest and utility in the present-day quality activities. It would be good to know, if the modern tools like 6 Sigma of DoE would have made significant contribution in the 1960s, the way they are providing cutting edge today. Would they be equally good or would have lost the shine?

Hagemeyer, Gershenson in their research titled Classification and application of problems solving of quality tools released in 2006, tried to give answer to this question. They say that, the use of quality tool has to happen at proper time in the process and time.

There are at least 25 popular and widely used quality tools. They find different application and they are used in different level of companies. Am Original Equipment Manufacturer (OEM) of international repute might be using a tool that the supplier of Indian OEM might not have even heard. Also the fact is that, a basic tools used for complex situation or used by a company at higher echelons of quality is waste of effort. Similarly, a company that has basic quality understanding that uses a high end tools is waste of money, resources and time as they may not be able to get best out of it.

While selecting a tool one must remember trio of parameters, the Effectiveness, Difficulty and Cost. The combination of three would decide which tool would find it's right application for the purpose.

However, selection of tool remains a mystery of sorts in the minds of business bosses and obviously the quality heads and quality professionals!

This paper makes an attempt to categories tools by stratification on the basis of the usefulness so that the user can choose those on the basis of the hierarchy assigned to it from the ability of the tool to deliver quality improvement in given situation.

Literature Review

A secondary data in relation to the quality tools was sought by referring to various papers and theses providing wealth of information on the quality, quality tools, cases studies of implementation and results earned out of rolling out a particular quality philosophy.

The effort began with attempt to understand how authors studied the tools at an individual level. Take example of Shanmugaraja (2014) who studied very complex tools like QFD and TRIZ used in combination and explained in his paper Quality improvement through the integration of Six Sigma QFD and TRIZ in manufacturing and service organizations. His study was in depth and was able to use very complex tools amalgamating with the 6 Sigma approach to form a model of his own. The combined tool proved good for defect rate coming down in manufacturing industry and customer complaints getting reduced in service industry. He found combined high-end tools provides never seen before quality improvement to a level of reduction by 95% to 99%. Keki Bhote the Director Emeritus of Quality for Motorola, who made Shainin Design of Experiment (DoE) popular amongst the automobile quality executives, explained the use of Variable search, Component Search, Paired Comparison and that was used as the book to refer by the quality professionals starting 1990. Another good study related to multiple toos combined together was done by Desai (2019) where in he followed a case of TQM approach product in which House of Quality or Quality Funcition Deployment (QFD), Scatter Diagram, DoE and Mistake Proofing (PokayYoke) were used together in a company related to radio frequency domain. These tools are not always interrelated but here was a very interesting case wherein he found out that QFD is more of a design tool than a Quality tool. Scatter diagram he found, is useful for understanding quality over intended use time of the product by using another tool of regression analysis along with scatter plot. Mistake proofing, they observed eliminates occurrence of defect or gives alarm when generated initiating quick action. This is the tool they found almost lead to zero rejection. DoE says Desai, is king of quality tool to improve the quality only if there is

already a good quality culture that has been setup in the organization. IT gives breakthrough improvement in exixiting quality levels. How basic quality tools like 7 Quality Control (7 QC) Tools can be used to bring in small and step by step improvements in quality, in the form of Continuous Improvement (CI) was explained by Magar, Shinde (2014).

Balsare (2012) worked on Quality Certification (ISO 9001) and her focus was on the HRS aspect. It gives a different view point on of the Quality System but did not provide any benefit to the study on quality tools. Jebarani (2007) too worked on the quality management system (QMS) as used in export focused manufacturing and provided advantage of employing QMS in the manufacturing industry but failed to say anything of importance to a student of quality or quality tools.

Kumar (1990) shared in his study a case study of a steel Industry in Odisha where a simple and then prevalent concept of Quality Control Circles (QC Circes of QCC) was effectively used in later part of 1980s to eliminate more than 90% of the issues they were facing. This grassroot level quality improvement effort was akin to Japanese efforts in 1950s that put them on the global map. The concept was to involve 100% of the people in quality improvement activity rather than engaging the 5 or 10% of the officers and engineers getting engaged in quality improvement process. Dasgupta (2011) conducted study in the Industry in West Bengal, mainly Kolkata, on the usefulness of QC Circle culture. He observed that though QC circle is a good concept, is having varying degree of success.

All the above examples were related to basic tools or basic quality systems throwing some light on its usefulness.

After the rush to study the basis quality tools and QMS, Total Quality Management (TQM) took fancy of the researchers for the obvious reason of popularity. Mani (2012) fond that two ways in which TQM is implemented contemporary and classical. He was not impressed with the Quality Guru or Quality practitioner-oriented implementation of TQM and put forward new TQM principle based on 40 factors which he feels should be used as concept and not a rigid framework pushed by Gurus.

Kulkarni (2017) was one such author who found us of TQM in both manufacturing and service industry and concluded that both the types of companies got benefited out of the implementation in the ofrm of all performance parameters of an industry, including of course the quality. She found that customer focused actions by engaged and inspired teams have made all the difference. TQM is about every one getting involved and that was what was visible. Another study on TQM by Ray, Suryyanarayana (2011) done in Indian Industries, was on the framework and associated quality tools. But contrary to the expectation of the author of this paper, his study did not have much coverage on the quality tools and his focus on the management approach only indicated that there is a long way, the companies in India to go before making any sizeable impact on the organizations performance by employing TQM.

The shift of research from for basic quality tools to QMS to TQM moved a notch up when Six Sigma (6σ) gained prominence. For example, the study of foundries in Agra who used 6 Sigma approach found interest in research by Kumar (2020). it was revealed that the process having multiple parameters that have prominent effect on the quality of the product, like process industry or industry line founds in this case Six Sigma plays a very critical and decisive role in hitting right parameters to provide best quality. The surprising part is once study is conducted to improve on one aspects of quality the quality professional get many other benefits in the form of cost reduction, productivity improvement, and reduced in pollution levels. Similarly, Kulkarni (2006) shared a study that caught the attention of the author since it is related to industry in Pune. He studied effect of 6 Sigma on manufacturing sector in Pune. His study indicated all around benefits to industries of any nature, any domain or any size. He similar to Dilip Kumar found that in addition to Quality, the gains extended to

financial efficiency and added that the customer satisfactions is also a side effect of this effort. Srinivasan (2016) studied 6 Sigma studied to core to understand why this tool has caught attention globally. He found a case where 700,000+ DPMO dropped to dead zero and a 30,000+ DPMO case reduced to mere 1500. He found that best of the earlier attempts would give you a level of 3 to 3.5 sigma scarcely reaching 4 Sigma. Where as this one is able to reach to 6-Sigma level and beyond, like the zero defect case.

As LEAN was getting executed by Toyota, its subsidiaries and suppliers in parallel to 6 Sigma implementation mainly by American companies and associated or related ferms, some one thought of merging the two and that immediately caught the attention of the researchers. Kumar (2020) for example conducted focused study on Lean-6σ Sigma Small and Mid-Sized Enterprises (SME). He found that with Lean-Six-Sigma the companies were able to improve quality level by 20%+ achieved and cost reduction by similar levels, which is too high from any standard. Prasad (2020) in another study in Pump Mfg. related to Induction motor manufacturing found how LEAN six Sigma provided improvements in Quantity (improved efficiency) and Quality but mentioned more about former than later leaving a gap in study of LEAN for quality.

The literature review on Lean or Six Sigma or Lean Six Sigma was limited to use of these tools in particular organization, geography (like in Pune) but did not cover the effect on quality in totality or in depth.

The Business Excellence Models like European Foundation Quality Model (EFQM) used in Europe, Michael Baldridge Quality Award for USA and Deming Award for Japan – extended to world are all examples of Business excellence model. India too have it's own in the form of CII-EXIM Business Excellence Model supported by Confederation of Indian Industry (CII) and Export Import (EXIM). These models are similar to TQM but go beyond the scope by covering every aspect of business that might have not been covered by TQM. Sedani, Mathuradas (2011) studied it to the depth along with the connectivity to QMS. They found that QMS does not help in any way for long term benefits but is kind of hygiene factor that needs to be in place before going ahead with the business excellence model. QMS may gie initial benefit, establishing quality and systems mindset but longer presence of QMS does not mean more benefits.

Research Gap

A lot of study was progressively done on basic tools, basic quality systems, business processes improvement techniques like TQM, cutting edge tools or cluster tools kine Six Sigma and LEAN and Lean Six sigma. All had contributed in part to add information about the tools. But how far these were able to provide gains by having right selection for right purpose is missing.

However, there is a gap in terms of understanding use tool for a given circumstance. There is not study to assign a usefulness index or usefulness level so that the user can decide to use a right tool for the right purpose. This part is sorely missing in so many efforts by the various authors.

Selection of the topic

Based on the inputs from the industry veterans and experts following points emerged on what deicides the quality levels.

Table 1. Factors affecting the Quality

Sr. No.	Parameter	Number of votes
1	Quality Culture the vary fabric of the organization	48
2	Involvement of the grassroot employees	28
3	Use of Quality Tools	28
4	Leadership commitment	18
5	Customer focus	16

Sr. No.	Parameter	Number of votes
6	Poper vision and Mission in relation to quality	12
7	Training	11

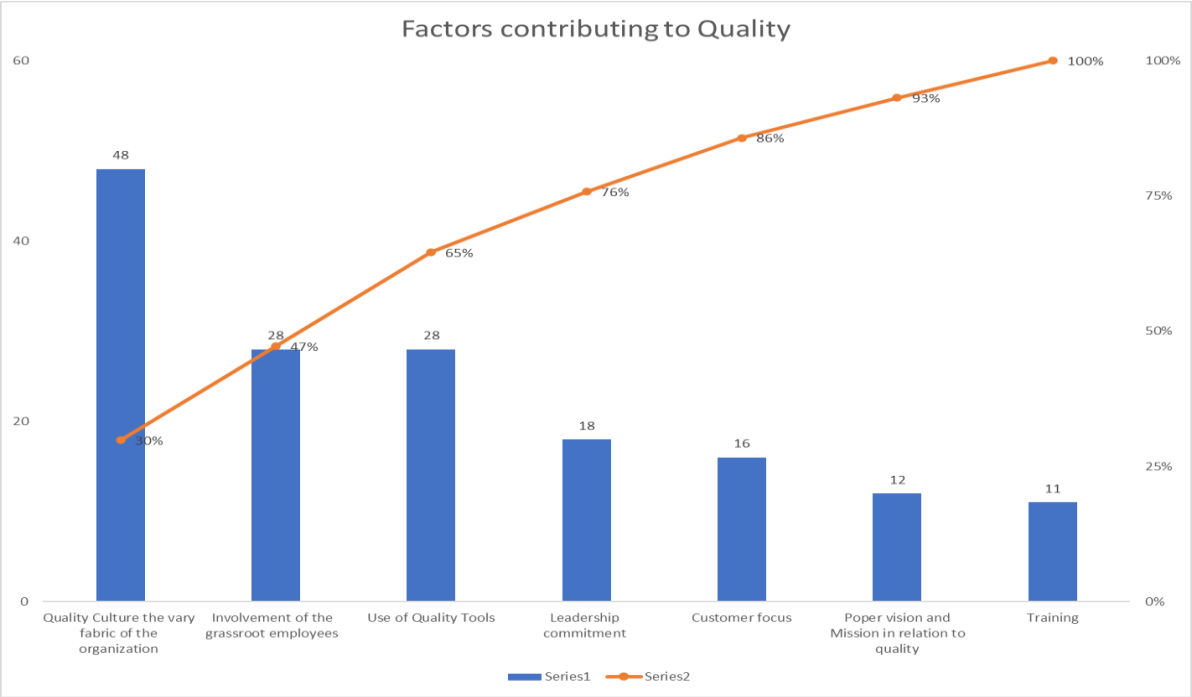

Figure 1. Factors affecting the Quality

It is observed that the Quality culture remains the top spot in deciding the quality level of an organization. The second spot is shared by involvement of all employees including the grassroot level employees and use of Quality Tools. The first two are more related to the sociological study rather than the study by a hardcore engineer and quality professional. The author has hence decided to go for "use of quality tools" as the subject for his study.

The study has suggested the application of of Quality tools as important factor and the research gap too has pointed out the non-availability of rating of quality tools. This is observation has led to selection of "Rating of Quality Tools" as topic for the study.

The study of quality tool was done on the basis of folloing criterila

1. Capability of issue resolution to the root to avoid recurrence
2. Effectiveness of issue resolution – does it get resolved buy it's on action or not
3. Overall process and system changes that improves quality by its own

The expectation from the evaluators, the experts in using the tools, the quality professionals is to share their experience in using these tools and tell how effective are they in 1 to 10 scale.

Research Methodology

Method followed to rate the quality tools:

1. Select tools based on the inputs from the few chosen experts
2. Conduct preliminary survey with the experienced quality professionals and finetune the survey list
3. Ask the quality professionals to provide rating for the tools they know (they may mis a few) and study the observations of all and assign the much awaited goodness number to each tool

List of quality tools

7QC tools, FMEA, Gauge R&R, PokaYoke, Statistical process Control (SPC), QFD, Scatter diagram, What What-not analysis, Multi-vary Chart, Paired comparison, Variable

search, Component search, Regression, Conventional or Classical DoE, TQM, 6 Sigma, Lean, Value stream mapping (VSM), Axiometric designs, CTQ tree, TRIZ, Business process reengineering, Chi Square test

Before understanding how these tools are rated, the article below explains what these tools are:

1. 7 QC tools – Magar, Shinde mentioned the 7 QC Tools as simplest of the quality tools that have been considered as age old quality tools which as per Ishikawa has capability of application in 95% of the cases and also capable of assisting in a breakthrough solution.
2. FMEA – it's a proactive tool used by deigners, quality professionals to take care of the issue in advance during deisgn itself or during process set up. It helps in identification onward to resolution of issues.
3. Gauge R&R –Not a quality tool as such but not folloing this can lead to defect production or lack of defect identification. IT is a hygiene that needs to be built in the production and quality systems.
4. Statistical process Control (SPC) – The reward of association of Deming and JSE is mentioned in ASQ as the use of statistical techniques to control a process or manufacturing mechanism. SPC is a method that keeps check on the process by inspection of parts at periodic interval and comparing it with the defined control limits. If there is any observation not meeting the expectations or rule of correctness, action needs to be taken. This ensures less variability leading to better and consistent quality.
5. PokaYoke (Mistake Proofing) is like a zero defect tool. It avoids production of defect by halting the manufacturing process or identifies a produced defect an avaoids it from going to the next station or to the customer.
6. Quality Function Deployment (QFD) also called as House of Quality – It is a designers technique to convert customer requirement in to engineering specification by also keeping manufacturing processes and competitors offerings in mind. Hauser and Clausing (1988) found QFD as map that draws interdepartmental attention and support for planning a quality design of the product. Various function can contribute to add information in the grid design of the QFD to induce quality at the design stage itself. But it is more related to meet the customer expectation rather than quality and is not a quality tool a process made for designers to buildgood quality designs.
7. Paired comparison – Bhote Keki, (1991), popularized Paired comparison which is a very simple but effective tool. For using this tool, one needs many pairs of ok and not ok components. Each pair is checked for the differences in the parameters or specification physically observed on the pair. If there are good number of pairs, the difference become very evdent and the parmeter can be further processed to confirm the real cause behind the failure.
8. What What-not analysis – In this tool the specification that are significant for quality ofr for defect are compared for its specification and the comparison is related to the good or bad mechanism or machine or component. The difference is sometimes subjected to test to confirm the significance of the difference. This way the root cause if found.
9. Multi-vary Chart – This is a Shainin Tool popularized by Keki Bhote. This gives part to part, within part and time to time variation in dimension of the part that gives clue in identifying defect. For e.g. if in a part with square cross section if the top left side is always smaller then one
10. Component search – This tool that is part of Shainin DoE is discusse in details in World Class Quality, by Bhote (1991). The main principle of this technique is identifying the defective component by swapping. This is a well define procedure unlike trial and error and it gives sure shot results identifying the culprit, if the process if followed well.

11. Variable search – This is similar to component search but is next level tool where in the swapping is done on the basis of the parpameters of the level of specification of a particular dimension. For example once a part is identified as culprit by component search, the part with varying levels of related dimensions are used for swapping and then a particular level of that dimension is generally found to carry the defect and hence gets identified as the root cause. This Bhote (1991) identifies as King of tools for defect identification.
12. Design of Experiments (DoE) – This King of Quality tools that many use for resolving very complex issues is having multiple ways of experimentation. This is a scientific way of trial and error where the experimentation is done not at random but follows a specific pattern proving breakthrough in issue resolution. Multiple levels of each contributing factors are used in the experiment and a complex calculation provides the main contributor of main contributors (with combined effect) for the failure. There are many ways of conducting DoE like conventional or classical DoE, Taguchi DoE and Shainin DoE. The last one is very simple to use and was made popular by Bhote (1991).
13. Total Productive Maintenance (TPM) – A seemingly unrelated tools that improves quality by proper maintenance of machines avoiding failure of variability reduction,
14. TQM – This quality philosophy which involves all functions of the organization to work qualitatively so that variation, defects in all related and unrelated processes are eliminated causing the manufacturing process more robust and less variable producing better quliaty. This however is more relate to the overall business improvement rather that just quality.
15. 6 Sigma – Comprehensive variability reduction tool, which actually is bouquet of multiple highly effective tools that work in tandem to resolve complex quality issues.
16. CTQ tree – Critical To Quality has two meanings. One for customer and other for the product or process. What it means is the dimensions, process parameters that are important to maintain quality
17. Value stream mapping– This is actually is a process improvement mechanism that avoids reasons for defects.
18. TRIZ – Inventive problem-solving tool that has gain fame in recent times and is not known to many. This is known for complex quality issue resolution.

METHOD

Initial study was conducted by contacting 12 expert quality professionals to include or exclude the quality tools under consideration. The criteria used was if the tool is really a quality tool or a business tool. If is a business tool does it give any quality benefit? If yes it is included if not it is excluded. Other criteria used were the extent to which this tool is known to the industry. IF it is not used often then is excluded.

Based on this the addition and deduction of the tools was done and is mentioned in the table below.

Data Collection and Data Analysis

Taking inputs by the quality professionals, following tools were selected for the study:

Table 2. List of Quality Tools selected

Sr. No.	Quality Tools	Part of study
1	7 QC tools	Included
2	FMEA SPC	Included
3	Gauge R&R	Excluded
4	Poka-Yoke (Mistake Proofing)	Included
5	House of Quality	Excluded

Sr. No.	Quality Tools	Part of study
6	Scatter plot	Included
7	Paired comparison	Included
8	What What-not analysis	Included
9	Multi-vary Chart	Included
10	Component search	Included
11	Variable search	Included
12	Regression analysis	Excluded
13	Design of Experiments	Included
14	TPM – Avoids breakdown n rejection	Included
15	TQM	Included
16	6 Sigma – comprehensive methodology	Included
17	Correlation	Included
18	Axiomatic design	Excluded
19	Value stream mapping	Got added later
20	TRIZ	Got added later
21	Business process mapping	Excluded

Note: Some unconventional tools that are not directly related to Quality but help indirectly like VSM, TPM, were considered while discussing about quality tools. VSM, TRIZ, got added later. The rating was done with following criteria by more than 40 senior quality professionals and 6 Sigma efforts:

1. The rating is done in 1 to 10 scale with 10 being most important from quality perspective and 1 being least important or least related to quality improvement.
2. 2 to 4 – Ground level or minor quality improvement
3. 5 and 6 – Historically has been used for quality improvement of moderate nature
4. 7 and 8 – Used mainly by expert quality professional for brining in remarkable improvement in quality.
5. 9 and 10 – Are the tools that are used after all other tools are used and this one comes in for breakthrough improvement.

RESULT AND DISCUSSION

Data collection on the selected tools

Rating was done after explaining the process to the professionals mainly Quality Heads and asking them to share their views on the goodness of the tool in relation to the ability to improve quality or get breakthrough improvement. Some of them were interviewed to understand how they have rated the tools and to avoid any wrong entry getting into the calculations.

Analysis

The data provided some observations like each tool is having different rating and some are having wide variability in the rating of the tool. This as the interviews suggested was due to lack of knowledge of the tool to the assessor. The data hence was corrected in following steps:

1. The average of rating of all the tools by each assessor was found out and then compared to see if any assessor has tendency to rate higher than normal or lower than normal. For this Box Plot was used and found that two assessors have rated the tools higher than the normal. These ratings were removed to ensure that the data is more homogeneous. The

normality too was checked and though it showed two peaks overall the data was found normally distributed.

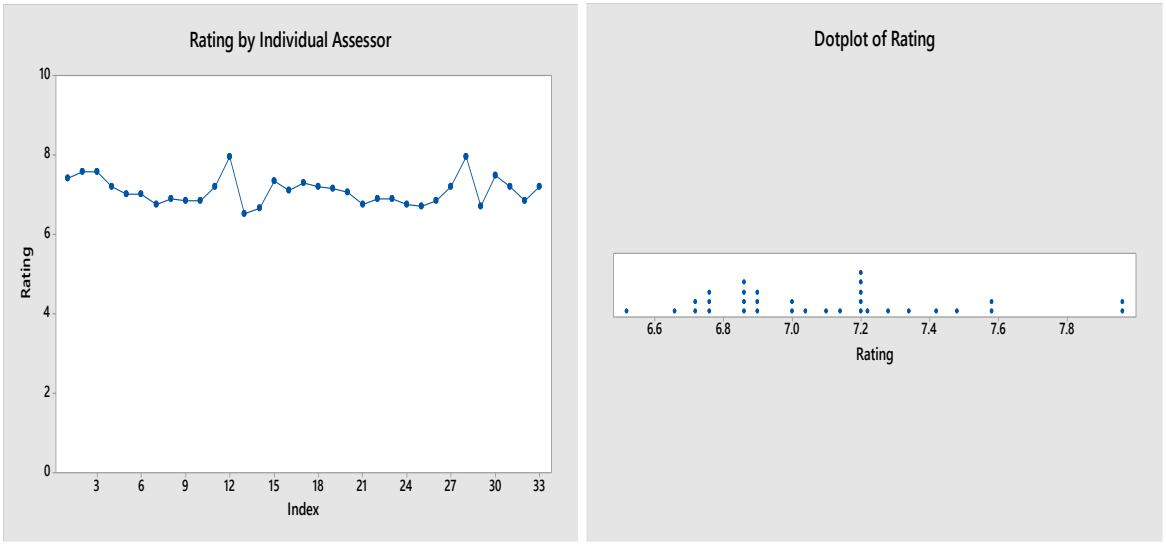

Figure 2. Average rating for all tools by QA professionals

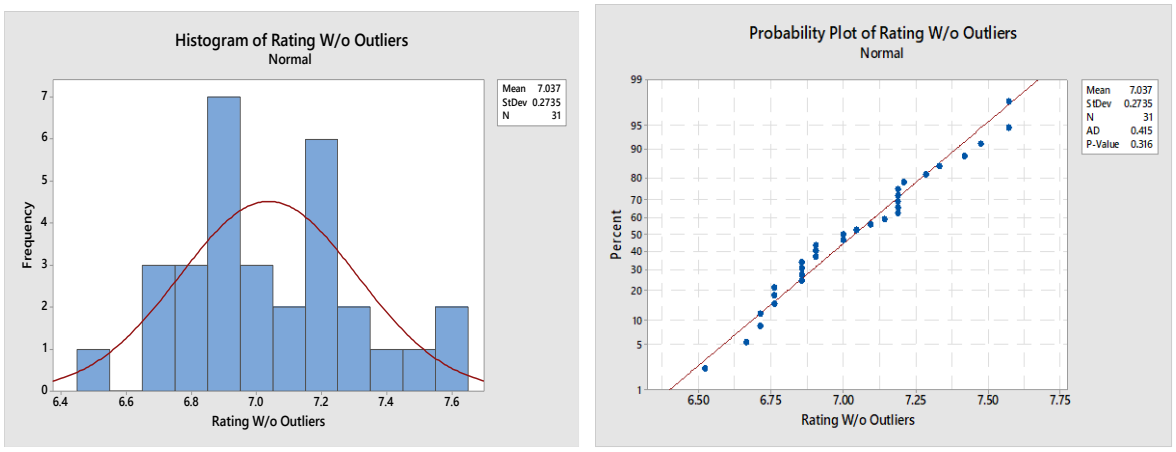

Figure 3. Ratings checked for Normality

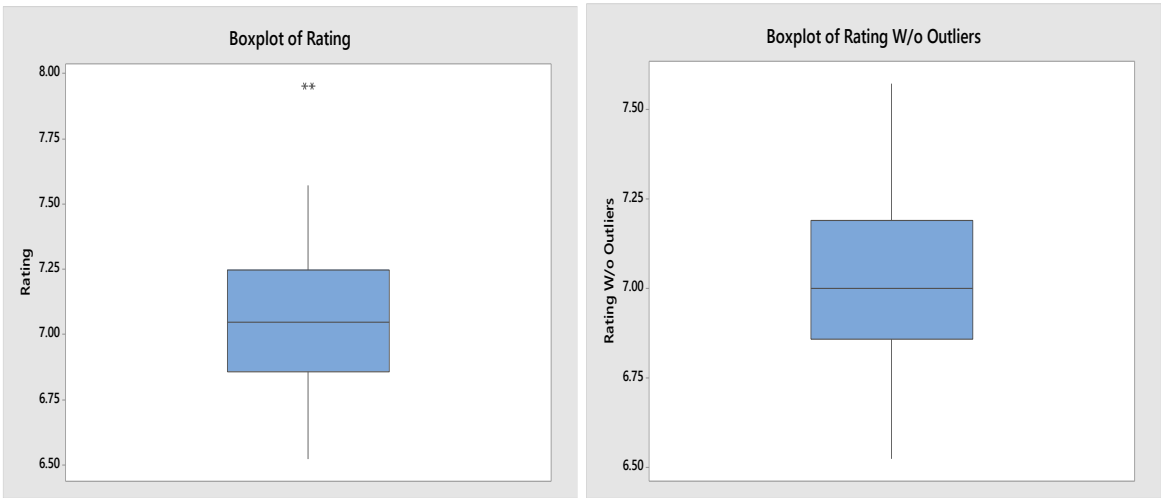

Figure 4. Quality Tools rating by QA professionals with and without outliers

2. Each tool also was tested for the out of normal rating by assessors and the first filter was the range of rating. For a 1 to 10 scale rating, a difference up to 3 is always considered normal, hence rating range of 4 or more was used to identify tools that had wide variability in rating. There were 4 such tools as mentioned below:
   a. 7QC Tools
   b. TPM
   c. FMEA
   d. TRIZ

   Box Plot was used to find out if there are any outliers and the same was found only in FMEA which had rating of 10 that goes beyond the whiskers.

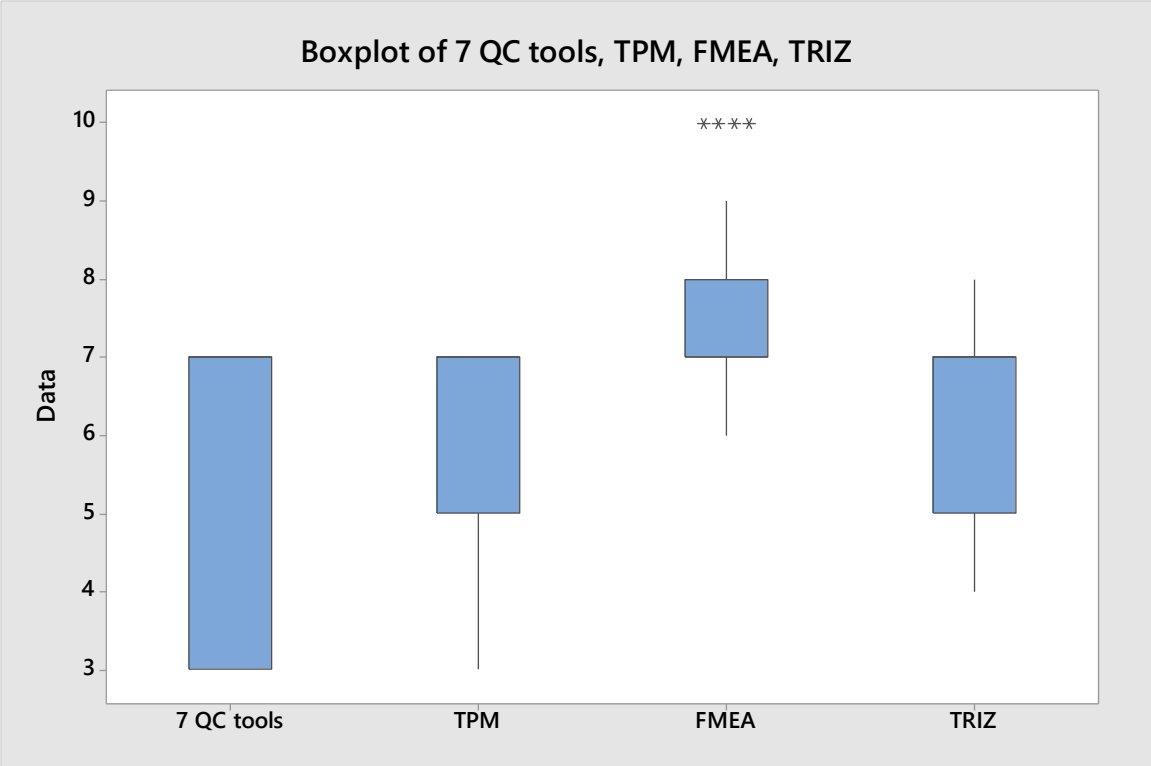

Figure 5. Boxplot of Tools with Range for rating at 4 or more

3. The analysis first and the second wa checked if ah changed sequence to see if there is any significant difference in the output, which was not observed.

How to arrive at the rating for each of the tool?

Since outliers were removed means is a acceptable central tendency, but the median serves a right way of looking at the rating. Same is explained in table below :

Table 3: Rating by the Quality Professionals

Sr. No.	Name of Quality tool or Systems	Median	Average
1	7 QC tools	5	5.24
2	SPC	5	5.92
3	Poka-Yoke	9	8.84
4	TPM – Avoids breakdown hence rejection	7	5.68
5	TQM	7	7.76
6	FMEA	7	7.40
7	Scatter plot	7	6.52
8	Paired comparison	7	7.40
9	What What-not analysis	8	8.00
10	Multi-vary Chart	7	7.00

Sr. No.	Name of Quality tool or Systems	Median	Average
11	Correlation	7	7.28
12	Component search	9	8.44
13	Variable search	9	8.80
14	Value stream mapping	7	7.40
15	Design of Experiments	7	8.24
16	6 Sigma – comprehensive methodology	10	9.68
17	TRIZ	7	6.16
18	Axiomatic design	7	7.33

Implications of Study

After the ratings were analyzed statistically the same was shown to some prominent Quality Professionals and following inference was drawn

1. The ratings are not always same and there is a good variability observed in the low end and high-end rating. This is because the high end tools are not known to all and low end tools are not used by many.
2. Age old tools like 7QC tools are having low rating though are used substantially as a startup tool for any issue
3. Some of the tools like 6 Sigma, DoE have gor consistent high rating and is favourite amongst the professionals

The SPC garnered lower rating. After discussion with the quality professionlas it was found that modern technology has built in controls that produce quality by default and the SPC is just a rechecking tool for many.

CONCLUSION

The quality tools have different degree of acceptance and usage. Some tools are used for generations and are used just because this is how it used to happen. However the modern trends adopted by new generation of quality professionals clearly favour high end tools and cluster tools. it however was very clear that the use of tool depends on the maturity of the organizations and OEMs are pushing use of quality tools on the suppliers to build quality in process. The authors concluded that the hierarchy of the tools can well be used for selection of the tools in the organizations.

REFERENCES

ASQ Journal *https://asq.org/quality-resources/pub*

Bhote Keki (1991) – *World class Quality*, Using DoE to make it happen – Amacon American Management association

Belsare Mrunal Nitin. (2012) – *Study impact of ISO-9001(2008) certification on selected hrm practices of large-scale automobile industries in Pune inthe period between 2002 and 2012* http://hdl.handle.net/10603/219675

Clausing Houser (2018) – *House of Quality - Harward Business Review May 2018*

Dasgupta, Ranjan (2011) – *Effectiveness of quality circles a study of some selected industrial enterprises in and around* http://hdl.handle.net/10603/155897

Desai Y. P. (2019) – *Use of TQM Tools to improve radio metric quality of Optical Remote sensing products* - http://hdl.handle.net/10603/269589

Juran Joseph (1987) – *Juran's Quality Handbook, 5th Edition*

Kulkarni (2006) – *The Role of 6-Sigma for Achieving Business Results in Manufacturing Sector With reference to Select Industries in Pune* http://hdl.handle.net/10603/155471

Kumar Abhay (1990) – *Quality circles in India a case study of Rurkela steel plant* http://hdl.handle.net/10603/128801

Kumar Dilip (2020) – *Exploring Sustainability Operational Excellence and Eco-Friendly Environment through Six Sigma in Foundries* http://hdl.handle.net/10603/323855

Kulkarni G. R. (2017) – *A critical study of total quality management in engineering industries* http://hdl.handle.net/10603/142431

Magar, Shinde (2014) – *Application of 7 Quality Control (7 QC) Tools for Continuous Improvement of Manufacturing Processes - International Journal of Engineering Research and General Science Volume 2, Issue 4, June-July, 2014*

Mani, T P (2012) – *Contemporary total quality management is indeed classical* http://hdl.handle.net/10603/105451

Mathuradas, Sedani (2011) - *A model for adopting good quality practices in industries and assessing its impact on manufacturing practices and performance* http://hdl.handle.net/10603/5398

Mohan Prasad, M (2020) – *Investigations on the implementation of lean practices in Indian pump manufacturing industry* http://hdl.handle.net/10603/340749

Ramkumar (2020) – *Some invstigations of process and productivity improvements in small and medium enterprises through lean six sigma implementation* http://hdl.handle.net/10603/309250

Ray, Suryynarayana (2011) – *Total quality management practices in India a study of selected companies* http://hdl.handle.net/10603/156724

Rosemmalelizabeth Jebarani, A (2007) – *Quality management systems of export industrial units in Tamil Nadu* http://hdl.handle.net/10603/125357

Srinivasan K. (2016) – *Investigations on achieving six sigma level quality through DMAIC phases in small size furnace manufacturing environment* http://hdl.handle.net/10603/196092

Shanmugaraja M (2014) – *Quality improvement through the integration of Six Sigma QFD and TRIZ in manufacturing and service organizations* http://hdl.handle.net/10603/26258