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Research Paper

A Study On Quality Problem Solving Techniques Used In Manufacturing Industries

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ABSTRACT: *Whether the problem is small or complex, its tendency to arrive is a normal and common phenomenon. Common problems may be leading to low efficiency and effectiveness for which industries are most worried. Detection of problem, analysis of problem and correction of problem are three main components for problem solving. For the problem solving there are various techniques which industries are following. In this paper the authors have analysed different types of problem-solving techniques used in Industries and its impact on the problem. The objective of this paper is to study and analyse the understanding related to problem solving and related tools and techniques in manufacturing industries.*

KEYWORDS: *Problem solving, Six Sigma, Indian manufacturing, Lean, ISO 9001, Why-Why Analysis, Quality Tools & Techniques*

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I. INTRODUCTION

In production there are different kinds of problem faced at different steps which may affect the effectiveness and efficiency of the industry. (Gaikwad et al., 2016). The ultimate goal of the industry is to gain profit and for this effectiveness and efficiency play major role. So, to achieve the ultimate goal, one should realize the importance of problem solving in industry (Triantaphyllou, 2000).

There can be issues and problems faced due to the impact of 6M's famously known as machine, material, man, method, measurement and mother nature/environment (Kalantri & Chandrawat, 2013). The first step towards the problem solving should be to analyze the root cause of problem. The issues or problems may be complex or simple, but it needs to be identified and solved as early as possible to reduce the loss faced by industry (Ke, 2013).

There can be various approaches to solve a problem like six sigma, 5-why analysis, ISO 9000 etc. This paper presents a brief introduction to six sigma and 5 why analysis to give an overview of these techniques. A questionnaire was made on problem solving techniques used in Indian manufacturing industries to analyze the current scenario and how it is impacting the industries. Are industries ready for six sigma or not? In this paper a brief literature review, introduction to few techniques and theanalysis of questionnaire is presented (Meister et al., 2019).

II. LITERATURE REVIEW

Kalantari &Chandrawat in their paper stated different techniques of root cause analysis such as fishbone diagram, relationship diagram, tree diagram, 5W-1H analysis, Why-Why Analysis, Multivariate Analysis and Brainstorming (Kalantri & Chandrawat, 2013). They've stated six steps for solving a problem.

Firstly, understand the and clarify the issue, after that team has to be set up. Physical phenomenon of problem needs to be defined and then collect the details (why, how, what, when). Every viable cause should be taken into account and then analyse the causes and finally the human error should be kept separate. After the root cause analysis, the problem can be solved.

C.K. Ke in his paper states about optimized problem-solving solutions. He states that problem may be complex or simple a proper solution needs to be given. Past experiences, previous decisions made should also be analysed so that it may help in solving the present solution. Human ability to think about the problem is an important factor in solving a problem. Further, he has also explained about context-based utility and multi criteria decision analysis. How the user is interacting with machine and hidden causes should be analysed. From a collection of various proposed solution of a problem, an optimized solution need be to adopted for this a problem-solving solution formalization is used and the best process is adopted for a solving a problem (Ke, 2013).

Maximillian in his paper talks about the importance of manufacturing analytics. To achieve the breakthrough and to get marvellous results, analytics play a very important role in manufacturing. Manufacturing analysis (MA) here means the data analysis. MA helps to draw conclusions from raw data which leads to simplicity in solving. He further talks about descriptive, diagnostic, predictive and perspective are important for data analysis and vary with complexity of the problem. He concludes that MA is not much used in today's time but it is very important in solving the complex problems. Problem analysis directly supports MA. Therefore, there is a need to develop the importance of manufacturing analysis for problem solving (Meister et al., 2019).

Brasov explains about the problem-solving methods in machining process. He states that determining the right root cause of the problem is necessary which can be done by 5- why analysis (the common method which industries use). First of all, the situation needs to be understood which can be done by simply locating the point of cause. If the cause is visible, it should be verified so that, the cause is confirmed and if it is not visible, determine its consequences. Build the cause and effect relationship by 5 why analysis. After the complete analysis, there should be prevention and correction measures to solve the problem (Brasov, 2017).

Hayat M. Awan in his paper gives the full review on ISO 9000. His findings majorly state that demand for certification of ISO 9000 is growing rapidly for all types of industry except local industries and the main reasons are internal quality management, market reputation and customer requirement. He also states that training for ISO 9000 is an essential thing for each member of industry. It is a problem-solving technique and majorly focuses on reduction of rejection rate, increases quality and also helps for easy communication among other members (Awan & Bhatti, 2003).

Adan Valles, in his paper explains about the implementation of six sigma. The main objective of six sigma is to achieve 3.4 defects per million opportunities. There are 5 phases define, measure, analyse, improve and control. Define phase is where the problem is understood. Measure phase is used to determine the process capability and analyse phase is for analysing the data at ground level. Improve and control phase are for solving of problem. He concludes that six sigma is helps in reduction of nonconforming units and quality improvement (Valles et al., 2009).

Six Sigma is defined as problem solving technique, developing the operational procedure and a method for the deep analysis of industry. This all are done by various statistical tools which are used to analyze things. DMAIC and DFSS (design for six sigma) are two basic methods for six sigma in which DMAIC is used for improvement in process and DFSS is used while developing a product (Tjahjono et al., 2010). There are various benefits of six sigma, majorly problem solving, improving the effectiveness and efficiency of process by reducing the cost and defects. As it studied from old data, the use of six sigma is increasing day by day and not only manufacturing industries but various other sectors are adopting this technique. Small industries are still not using it.

Findings: At various steps industry come across variety of problems resulting in decrease ofeffectiveness and efficiency which needs to solved. For this, industry follow various techniques to analyze and solve the problem. Among this analyzing the root cause is determined as a primary and most important step in most of the techniques. Each technique has its own specialty. As the time is growing the implementation of six sigma is increasing and determined as effective technique. Now not only in manufacturing problems but to solve design problems, six-sigma is also used. SME's are still not using problem solving technique.

In late 1980's, Motorola in USA developed this technique and came out to be a successful and impacting technique. Till that time, Total quality management (TQM) or Theory of constraints (TOC) were in practice. The main focus was on improving quality, reducing cost, increasing process capability and increasing efficiency (Valles et al., 2009).Six sigma works on 3.4 million defects per million opportunities (DPMO) and 1.5 sigma shift in capability of process, where sigma is standard deviation. For this, it follows DMAIC and DFSS approach. Define, measure, analyse, improve and control are 5 phases for DMAIC which mainly focuses

on process capability improvement. This technique can only be used in improvement and not in while developing a new product. So, for this DFSS was introduced. It works on identify, design, optimize and validate. Six sigma uses various statistical tools for analysis like design of experiment (DOE), Process capability analysis (PCA) etc. These tools help in analysing the problem. As the analysis of root cause is important, six sigma uses fishbone diagram for analysis of root cause (Tjahjono et al., 2010).

The use of six sigma has grown up in 2000's and was majorly adopted by manufacturing industries. Service sector has also started using this technique and only SME's have still not adopted to large extent. There is a training required for six sigma which include investment for making employee ready for six-sigma. This can be the reason for small industries are not adopting (Nonthaleerak & Hendry, 2006).Six-sigma is defined as problem solving technique, a business improvement method and a statistical tool. New improvement in six-sigma is going with time like customer centric six sigma quality management (CSSQM) and FIT sigma. These are new models which are specification oriented like CSSQM focuses on quality management and integration of LEAN with six sigma is termed as FIT sigma (Venkatesh & Sumangala, 2018).

5 why's analysis is basically used for analysis of root cause. It involves basic 5 questions related to given problem so that solution to those question may result in identification of real cause of problem. WHO, world health organization raised the issue related to the use of this technique in health industries. It was used in Toyota production system and six-sigma also uses this in identifying the root cause of problem. Identifying the major cause of a problem becomes easy by using this simple technique (Ke, 2013). 5 why analysis helps to make the cause and effect relationship which is very helpful in determining the effect before and after correcting the cause. Recurrence can also be prevented by this diagram. Helps in taking immediate action if cause is directly visible and if cause is not visible the why's analysis must be continued till the time the cause is identified (Brasov, 2017). This technique also helps in eliminating the unnecessary non value added activities, reduction in waste, lead time can be reduced, enhancing just in time, helps in maintaining high quality etc and thus improving the efficiency and effectiveness of process which was the ultimate goal of a particular industry (Card, 2017).

III. RESEARCH METHODOLOGY

The main objective of the survey was to study the current scenario in manufacturing industries about the problem-solving techniques. Type of problems faced, how industry is dealing with raised problem. How techniques like 5 why's analysis, ISO 9000 and six-sigma are helping in problem solving. A quantitative study has been performed using a questionnaire related to problem solving techniques. It was circulated to various industry related people, faculties and students through E-mails and LinkedIn to see the actual scenario of type of problem faced, type of technique used, average time to analyze the root cause and how much India is ready for six sigma and other techniques. A questionnaire was developed with 18 questions based on a 5-point Likert scale. Total responses considered for analysis are 203 in which the people are from various working area and a wide range of experience too. The experience varies from fresher to more than 15 years. The sampling was done based on the concept of snowball sampling. The software used for the analysis was Minitab 19.0 and Microsoft excel 2013 was used to collect the data of the survey.

IV. DATA ANALYSIS

The reliability test was performed for the collected data on Minitab19 and Cronbach alpha value came out to be 0.7528 which is relatively good and proves the data as consistent so that further analysis can be done. There are 40% industrialist, 28.2% business owner, 8.4% faculties, 22.2% students and 1.2% others in the collected data.

Table 1: Shows the statistical mode of each item w.r.t area of working

Items	B	I	F	S
How much do you know about problem solving?	VA	VA	A	A
How often the analysis of root cause is correct?	O	O	O	S
How often do you follow the correct procedure for problem solving?	O	O	O	S
How far do you find concept of LEAN helps in problem solving?	MS	MS	MS	MS
How far do you find "WHY's analysis" helps in problem solving?	HS	HS	MS	MS
How far do you find ISO-9000 helps in problem solving?	MS	HS	MS	MS
How much your industry is ready for six-sigma?	AR	MR	MR	MR
According to you, how much beneficial is problem solving for the industry?	HB	HB	HB	HB

Legends used in Table-1:

- B – Business owner
- I – Industrialist
- F – Faculty

- S – Student
- VA – Very Aware
- A – Aware
- O – Often
- S – Sometimes
- MS – Moderately satisfied
- HS – Highly satisfied
- AR – Almost ready
- MR – Highly ready
- HB – Highly beneficial

Table 2: Descriptive statistics of data

Item	$\bar{x}$	SE	σ	Min	Me	Max	Mo	N_{Mo}
I1	3.18	0.08	1.09	1	3	5	4	70
I2	3.48	0.06	0.88	1	3	5	3	79
I3	3.55	0.07	0.96	1	4	5	4	78
I4	3.27	0.07	0.96	1	3	5	3	87
I5	3.63	0.07	1.03	1	4	5	4	65
I6	3.25	0.07	1.07	1	3	5	3	74
I7	3.15	0.07	1.06	1	3	5	3	78
I8	4.15	0.07	1.01	1	4	5	5	95

Legends used in Table-2

- I1 - How much do you know about problem solving?
- I2 - How often the analysis of root cause is correct?
- I3 - How often do you follow the correct procedure for problem solving?
- I4 - How far do you find concept of LEAN helps problem solving?
- I5 - How far do you think WHY's analysis helps in problem solving?
- I6 - How far do you find ISO-9000 helps in problem solving?
- I7 - How much your industry is ready for six-sigma?
- I8 - According to you, how much beneficial is problem solving for the industry?
- $\bar{x}$ - Mean of the data
- SE – Standard error
- σ – Standard deviation
- Mo – Mode
- Me – Median
- N_{Mo}– Count of the Mode
- Min – Minimum
- Max – Maximum

Now, to check the internal consistency of the data before further detailed statistical analysis, a Cronbach alpha test was done. The test and the result have been shown below:

Cronbach's Alpha
0.8222

The Cronbach alpha of 0.82 shows the good internal consistency of the data.

4.1 How much do you know about problem solving?

The above table clearly depicts that business owner and industrialist are more aware about problem solving as compared to faculty and students. The descriptive statistics gives the mean as 3.481 with standard deviation as 0.95 for industrialist. This shows that almost 70% are aware of problem solving. Whereas students are very less aware as mean is 2.556 with SD 1.056. This data clearly gives inference that academic should involve the problem solving so that students get aware of this as the demand for this is growing.

4.2 Analysis of root cause

The stats show that industrialist have high frequency of getting the root cause correct, with mean 3.654 and SD 0.8087.

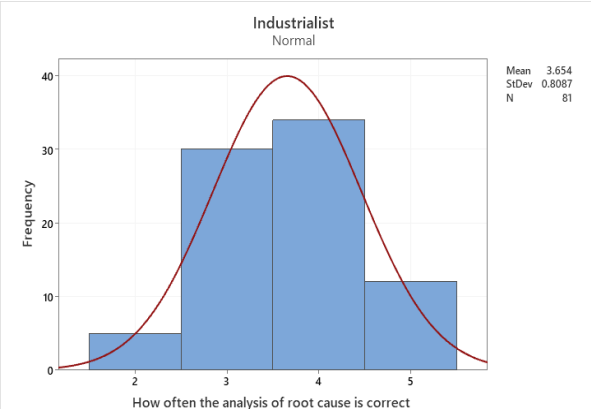

Figure 1: Histogram showing distribution of opinion of Industrialists claiming their root cause analysis is correct

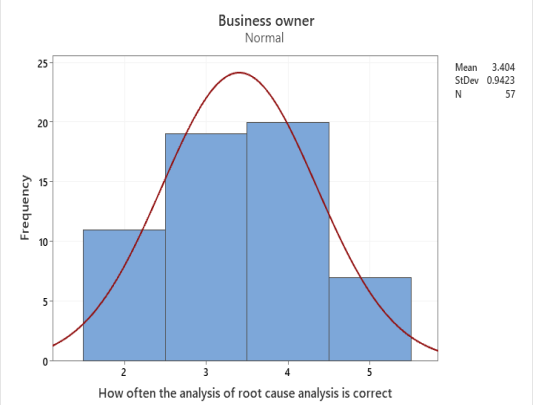

Figure2: Histogram showing distribution of opinion of Business owners claiming their root cause analysis is correct

The histogram clearly shows that mostly the root cause analyzed by an industrialist and business owner is often correct as compared to others.The data also shows that people from industry and the business owner often follow correct procedure for solving the problem. For example, the DMAIC approach. This can be clearly understood, as they know more about problem solving (stated before) and their analysis of root cause is often correct that simply means that they are following the right procedure for solving a problem.

4.3 Comparison with respect to experience of working

Below is the table of statistics which is used for comparing different parameters with work experience of people. '0' refers to a fresher, '1' refers to experience of less than 7 years, '2' refers to experience of 7-15 years and '3' refers to experience of more than 15 years.As it can be clearly seen that people with experience of more than 15 years knows better about problem solving as compared to others. The highest mean 3.5 and lowest SD of 0.964 clearly supports the analysis.In case of getting the root-cause analysis correct, the people with less than 15 years of experience except freshers, are getting slightly better results as compared to people of more than 15 years of experience. Statistics also shows that people with high experience mostly follows the correct procedure for solving a problem.The mean of 3.77 and SD of 1.066 clearly supports the analysis.

Table 3: Statistics of comparison of experience with different parameters

Item	Experience	$\bar{x}$	SE	σ	Me
Knowledge about problem solving	0	2.7	0.1	1.0	3
	1	3.4	0.1	1.1	4
	2	3.4	0.2	1.0	4
	3	3.5	0.2	1.0	4
How often the analysis of root cause is correct	0	3.3	0.1	0.8	3
	1	3.6	0.1	0.9	4
	2	3.6	0.2	0.9	4

	3	3.4	0.2	0.9	3.5
Correct procedure followed	0	3.4	0.1	0.9	3
	1	3.8	0.1	0.9	4
	2	3.4	0.2	0.9	3.5
	3	3.8	0.2	1.1	4

4.4 Problem solving techniques

The questionnaire had three questions which were based on techniques of problem solving that included concept of LEAN, Why's analysis and ISO-9000. The reason for research on these techniques is that, earlier studies shows that they are used maximum and are most effective. Below is graphical summary which was developed in Minitab19 using the responses of only industry related people and the business owner. Concept of LEAN which was developed by Toyota production system, focuses on making flow i.e. flow of things should not stop. The value stream map helps in making the overall summary of plant which is used for analyzing the root cause and further solving it (S.J. Thanki & Jitesh Thakkar, 2010). ISO-9000 is a standard which majorly focuses on quality management. Maintaining quality as per customer requirement is very important. For this effectiveness and efficiency should be higher. Following the standards helps in reducing the problems and hence increasing the efficiency (Awan & Bhatti, 2003).

Why's analysis is a technique of RCA. 5 basic questions need to be framed so that a solution helps in detecting the cause and effect for the problem. The analysis is based on comparing these techniques that in present scenario which technique is mostly used by industry.

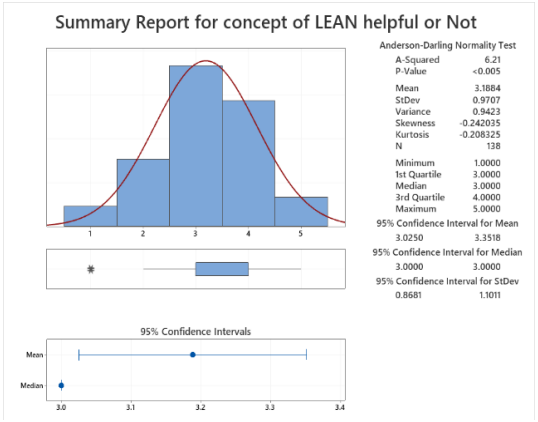

Figure3: Distribution & statistics of opinion of Industry professionals & business owners against the helpfulness by the use of LEAN.

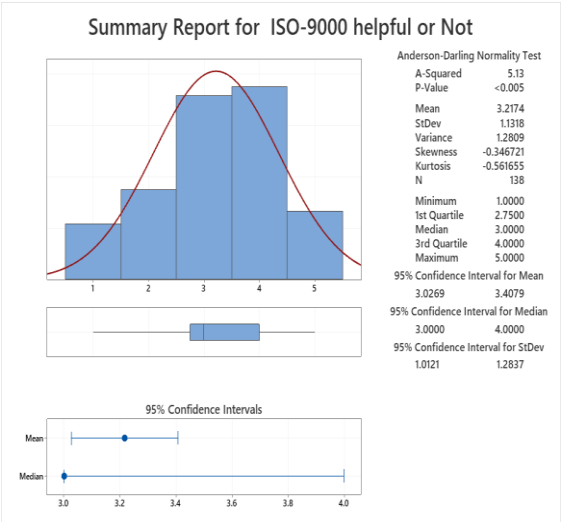

Figure4: Distribution & statistics of opinion of Industry professionals & business owners against the helpfulness by the use of ISO 9000.

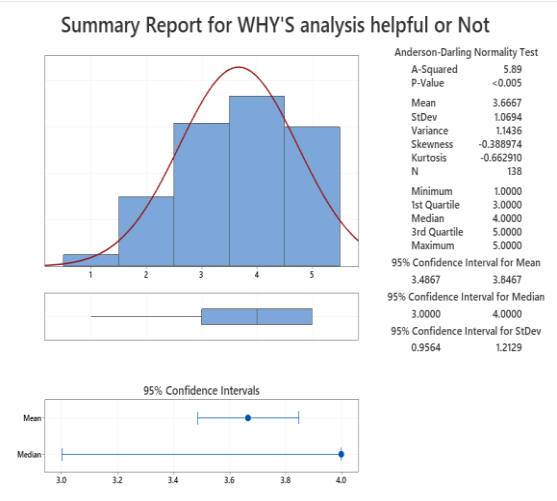

Figure5: Distribution & statistics of opinion of Industry professionals & business owners against the helpfulness by the use of why-why analysis.

Results from graphical analysis.

- All three techniques have mean around 3.3, this shows that each technique is significantly helpful.
- Clearly, the mean of 3.6667, SD 1.0694 and median of 4 shows that Why's analysis is most helpful among these three techniques. This can also be seen through quartile. Maximum responses lie between 3.5 and 4.
- There are least number of people who think Why's analysis is not helpful.
- The variation is highest in ISO-9000, as it has maximum SD of 1.1318.

4.5 Is industry ready for Six sigma?

Six-sigma is problem solving technique which is presently found to be most effective to manufacturing and service sector. But the question is "Are industries ready for six sigma or Not?". To find the solution of this the research has been done.

Table 4: Statistics showing how much industries are ready for six-sigma

Item	Is industry ready for six-sigma?
Mean	3.2
SE Mean	0.1
StDev	1.1
Median	3
Mode	3
N for Mode	47

Mean of 3.1812 shows that industries are moderately ready for implementation of six sigma. And standard deviation of 1.0957 shows good amount of variation. As per statistics, only 10.14% of respondents says that industries are complete ready for six-sigma, 31.15% says that its almost ready, 34.05% says moderately ready, whereas 8.69% says that industries are not at all ready for six sigma. It can be easily stated that only few industries are fully ready for six-sigma but other industries are moderately ready that means in future they are ready to adopt this technique.It can be concluded that present scenario in industries is that they are well aware of this problem-solving technique and are ready to implement in their industries.

4.6 Is problem solving technique beneficial for the industry?

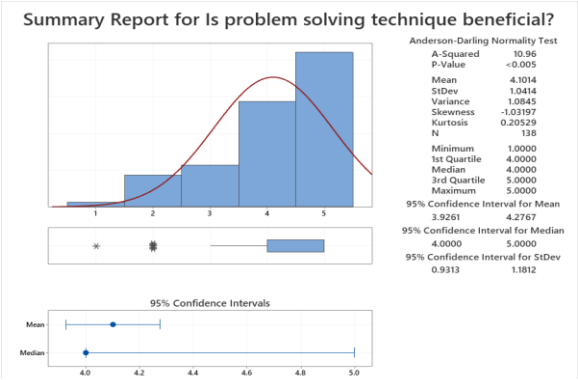

Figure6: Distribution & statistics of opinion of Industry professionals & business owners to claim that problem solving technique they've used has been helpful or not.

The graph clearly shows that majority of people believes that problem solving techniques are highly beneficial. The mean of 4.1014 clearly supports the conclusion. Whereas only 1.15% of industrialist and business owner believes that it is not at all beneficial. It can be concluded that overall industries believe that problem-solving techniques helps in diagnosis of cause, analyzation, improvement and control. This will ultimately increase effectiveness and efficiency of industry which was their ultimate goal.

After the detailed descriptive statistics, the results were further analysed to check whether the opinion for different question asked to different group were significantly different or not. For this, we have used ANOVA as a tool.

Table 5: Hypothesis formation for ANOVA

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	$\alpha = 0.05$

Table 6: Result of ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Items	6	44.56	7.427	7.32	0.000
Error	1414	1435.55	1.015		
Total	1420	1480.11			

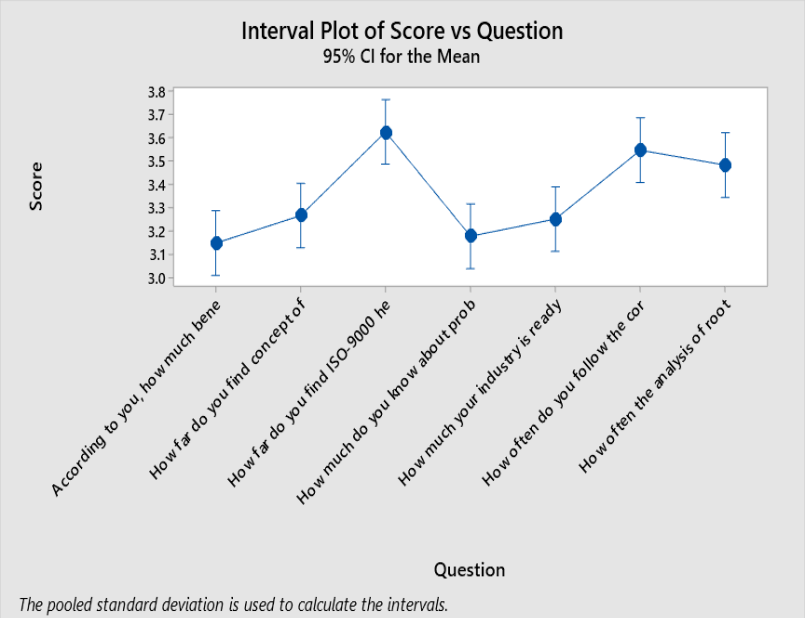

Figure7: Interval plot showing the difference of opinion of people from different sectors to every question.

The p-value clearly indicates that the null hypothesis has to be rejected as it is less than the value of alpha which is 0.05. Therefore, we do have sufficient confidence to reject the null hypothesis. Thus, we can say that there is a significant difference in the opinion of different groups to different questions.

V. CONCLUSION

The study of various techniques of problem solving was conducted and a quantitative study was made through a survey. The results conclude that more awareness or knowledge is required in problem solving as in present scenario only experienced people know more about problem solving. The analysis of root cause plays an important role while solving a problem and most of people from industries and business owner are following right procedure of RCA. There are several techniques which can be used for solving a problem but among them Why's analysis is mostly used in present time but as intensity of problem are growing, six- sigma is becoming an important part for industries making them to adopt this technique as it is more effective than others. The results have shown that industries are moderately ready for six-sigma, this means in future they will definitely implement. Survey analysis has quoted that problem-solving techniques are very beneficial for industry, which are directly meeting the industry's ultimate goal of increasing efficiency and effectiveness.

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