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A study on the Ishikawa's original basic tools of quality control in South American companies: results from a pilot survey and directions for further research

Abstract

Purpose – The main objective of this study is to revisit Dr. Ishikawa's statement: "*95% of problems in processes can be accomplished using the 7 Quality Control (QC) tools*" from his book "What is Quality Control?". The authors are interested in critically investigating if this statement is still valid nowadays. It involves the analysis of the usage of the 7 QC tools in the manufacturing and service sectors and the benefits, challenges, and critical success factors (CSF's) for the application of the 7 QC tools.

Design/methodology/approach – In order to evaluate Kaoru Ishikawa's statement and how valid his statement is for manufacturing and service industries nowadays an online survey instrument was developed, and data collection was performed utilizing a stratified random sampling strategy. The main strata/clusters were formed by senior quality professionals working in operational excellence, quality consultants, quality directors, quality engineers, quality managers and quality supervisors working in both manufacturing and service sectors from South American companies. A total of 97 participants from different countries in South America responded to the survey.

Findings – The main finding of this study is that only about 20% of respondents felt that the original 7 basic tools of QC can solve above 80% of quality related problems in their businesses. This is quite different from the findings reported by Dr Ishikawa in his work in the 1970s and 1980s. Another relevant finding presented in this paper is that Pareto Analysis, Histograms and Cause and Effect analysis are the most used tools in both manufacturing and service sectors. The least used tools are Scatter diagram and Stratification. The common benefits from the use of seven basic tools of QC in both manufacturing and service sectors include: helping people to define, measure and analyse the problem areas or even prioritize them; providing some form of structure to the problem-solving efforts; helping the organisation with continuous improvement projects and determining the root cause of the problem under investigation. This paper also revealed that the 7 QC tools proposed by Dr. Ishikawa were least used by Human Resources (HR), Information Technology (IT) and Finance functions. This work presents a list of Critical Success Factors required for the proper application of the 7 QC tools.

Research limitations/implications – All data collected in our pilot survey came from professionals working for South American companies. So, this paper does present limitations in terms of generalization of the results. Also, data was collected at an individual level, so parameters such as the inter reliability of judgements on a particular survey item, could not be evaluated. It is important to highlight that n=97 is a low sample size, enough for a preliminary survey but reinforcing the limitation in terms of generalization of the results.

Originality/value – Authors understand that this is the very first research focused on challenging Dr. Ishikawa's statement: "*95% of problems in processes can be accomplished using the 7 Quality Control (QC) tools*" from his book "What is Quality Control?". The

results of this study represent an important first step towards a full understanding of the applicability of these tools in manufacturing and service industries in a global scale.

Keywords – Ishikawa, 7 Quality Control Tools, Survey.

Paper type – Research paper

1. Introduction

In an increasingly competitive world, cost-effectively providing good quality products and remaining profitable has become even more critical. The use and applications of quality tools and techniques are part of Quality Management systems methodology and practice and used within a problem-solving framework are essential to facilitating quality and process improvements. Quality professionals have their own set of tools and techniques to solve quality-related problems in organisations (Revelle, 2012; Hellsten and Klefsjö, 2000). According to McQuater *et al.,* (1995), tools and techniques are practical methods, skills, means, or mechanisms applicable to problem-solving tasks. The development of quality management was influenced by several American and Japanese Quality "gurus," one of which was Dr Kaoru Ishikawa. Dr Ishikawa is known for his work on companywide quality control, quality circles, and education and training in the use of continuous improvement. He put forward seven basic tools which he stated were vital for problem-solving, these include Check Sheets, Histograms, Pareto Analysis, Cause & Effect Diagrams, Control Charts, Scatter Diagrams, and Stratification (Mach and Guaqueta, 2001).

In his book "Introduction to Quality Control" Ishikawa (1990) stated, "the quality control tools, if used skilfully, will enable 95% of workplace problems to be solved and intermediate and advanced statistics are needed in about 5% of cases". However, Ishikawa was not very prescriptive outside of this statement and did not elaborate or explain where this figure came from or how it could be measured.

This research challenges Ishikawa's original statement that 95% of problems can be solved using his seven quality control tools. This statement has not been challenged or studied to date. There are many unknowns around whether his statement was solely referring to the use of the tools in the manufacturing sector or across all sectors. It is also unclear whether specific tools have a higher percentage contribution to the problem-solving process than other tools or if each tool has an equal percentage contribution; for example, what percentage does a scatter diagram make to the overall problem-solving effort? The use, effectiveness, and application of the seven quality control tools in other business functions or support departments outside of manufacturing and production are also unclear.

This research will explore the extent of the use of the 7 QC tools in other business functions apart from production and manufacturing, especially in a typical manufacturing company. The research also analyses the level and frequency of usage of the 7 QC tools, some of which are used infrequently or rarely while others are in use frequently.

The remainder of the paper is as follows, section 2 describes the literature, followed by research methodology in section 3. The results are explicated in section 4, followed by discussion and implications in section 5. The conclusion, limitations, and scope for future research are elucidated in section 6.

2.0 Literature Review

The seven traditional, or the Basic Seven Tools of Quality Control, developed by Dr Kaoru Ishikawa, are a set of graphical techniques identified as being most helpful in troubleshooting issues related to quality (Kiran, 2017). The tools can be deemed "basic" because individuals with little or no training in statistics can use them to solve most quality problems.

Quality Control (QC) consists of developing, designing, producing, marketing, and servicing products and services with optimum cost-effectiveness and usefulness, which customers will purchase with satisfaction. To achieve these aims, all the separate parts of a company must "work together" (Ishikawa, 1993). Deming and Ishikawa stated that companies' main problems were within their processes (Suárez-Barraza and Rodríguez-González, 2019). Ishikawa believed mainly in the use of simple methods to work together on solving problems and removing barriers to improvement, co-operation, training, and education using Quality Circles, teamwork, and simple tools (Tummala and Tang, 1996).

Within the field of quality management, there appears to be no shortage of literature that describes the application of the seven basic QC tools and other techniques in various depths. Many of the quality gurus have written about Quality management tools and their use including Juran (1988) and Ishikawa (1976) as well as other authors cited here including Bamford and Greatbanks (2005), Dale and McQuater (1998), Barker (1989), Bunney and Dale (1999) and Asher and Dale (1989).

Much has been written on the benefits of quality tools by authors such as Bamford (2005), Tennant (2001) and Mach and Guaqueta (2001) for highlighting complex data in a simple visual manner, evaluating areas that cause the most problems; enabling prioritization of problem areas, showing relationships between variables; establishing root cause, showing the distribution of data (Bamford, 2005; Tennant, 2001; Mach and Guaqueta, 2001). The main benefits of the quality tools are to increase the communication between operators and management, detection, and prioritization of problems, followed by organisation of potential causes which results in problems (Dale and Shaw, 1991; Dale *et al*., 1997; Marsh, 1993). According to Bamford (2005) and Ahmed and Hassan (2003), quality tools can be applied to any business processes and they should not be confined to just manufacturing processes.

Ishikawa (1990) stated in his "Introduction to Quality Control" that "*the tools, if used skilfully, will enable 95% of workplace problems to be solved and intermediate and advanced statistical tools are needed for about 5% of cases*". He further reiterated in his "What is Quality Control?" book in 1995 that "*95% of problems in processes can be accomplished by the use of the 7 QC tools*" and that in very complicated processes, advanced techniques and computers are a requirement. Ishikawa did not justify or corroborate these statements in any detail. He did state that most problems utilizing the Pareto principle were from 2 or 3 assignable causes, so eliminating these will halve the number of defectives, e.g., raise the yield from 60% to 80% or 90 to 95% so thus 95% of problem can be solved utilizing the 7 QC tools (Ishikawa, 1995).

According to Ishikawa (1985), quality is not just limited to the quality department, and to produce the right product that meets expectations, everyone in the company should participate in and promote quality control, including top management, every function within the company, and all employees. Dale *et al*. (1997) report that the use of tools and techniques is not as widespread and effective as might be expected and suggest that part of the problem is due to insufficient training in the use and application of the tools in problem solving scenarios and lack of a structured and systematic problem-solving framework available to quality professionals. According to Bamford and Greatbanks (2005), very few examples have been found where even the basic seven quality control tools, have been fully exploited. Lamb and Dale (1994) have described the tools as too simplistic in some cases and not appropriate. According to McQuater *et al.*(1995), the typical difficulties with the use and application of tools and techniques: are poorly designed training and support; being able to apply what has learned; inappropriate use of tools and techniques; resistance to the use of tools and techniques; failure to lead by example; imperfect measurement and data handling; not sharing and communicating the benefits achieved.

The difficulties encountered in applying the quality management tools and techniques in different areas of the business and for different applications relate mainly to the status of the improvement process and the resources available to facilitate their introduction and subsequent use (Bunney and McDale, 1997). Other challenges include lack of discussion or elaboration from Ishikawa on the use of the tools outside manufacturing and the incapability of the six of the seven tools in dealing with non-numerical data (He *et al*., 1996).

McQuater *et al*. (1995) discussed that to ensure tools are used efficiently and effectively, several critical success factors (CSF's) are required. These CSF's include full management support and commitment; effective, timely, and planned training; a genuine need to use the tool or technique; defined aims and objective for use; a co-operative environment and backup and support from improvement facilitators (Hing Yee Tsang and Antony, 2001). Understanding the goal of utilizing a certain type of tool or technique, its pre-requisites, benefits, and obstacles in implementing is critical to success and use (Spring *et al*., 1998).

Bamford and Greatbanks (2005) have cited several studies by Scheuermann *et al*. (1997) and Ahmed and Hassan (2003), which have demonstrated that some QC tools are preferred and applied over others. Yasin *et al*. (1991) state that even when these tools are utilized, a piecemeal approach to implementation often results in sub-optimal performance or, indeed, a complete failure. There is much information in the literature about the cost benefits of problem-solving and the costs of quality. While the literature does not discuss specific examples of the ramifications or costs of using the "wrong" QC tool in problem-solving - many authors refer to applicability and use of specific tools in specific institutions (McQuater *et al*., 1995; Dale and Shaw, 1991 and González-Benito *et al.,* 2003). The complexity of problem-solving means utilizing the wrong tool can lead to the incorrect root cause and corrective action and having to go back to the proverbial "drawing board" and start again which would costs organisations several thousands of dollars. Bunney and Dale (1997) discussed that a single tool/technique could not be expected to be a solution to all issues, while González-Benito *et al*.(2003) discussed the importance of utilizing a combination of tools show relationships and highlight differences. The "appropriateness" of a tool is a common theme in studies about the use and application of the right QC tool(s) (Bamford and Greatbanks, 2005; Spring *et al*., 1998). The importance of being able to utilize, classify tools and have the user identify the correct tool at the proper time in the problem-solving process cannot be underestimated (Hagemeyer *et al*., 2006).

Some of the difficulties with the use of QC tools include not knowing what quality tool to use; misusing a quality tool, using a quality tool for the wrong application; not knowing when to use a quality tool, and not applying a quality tools when one is needed (Hagemeyer *et al.*, 2006). Five difficulties in the implementation of quality tools were described by Bunney and Dale (1997) in their study as lack of time to utilize tools, lack of understanding of the tools and their applications, difficulties with terminology in tool usage, lack of resources available to utilize the tools and inflexibility with the application of the tools. The costs of using the wrong tool cannot always be estimated but leads to time loss, waste of resources, and costs involved in potential defects continuing to be unresolved with potential impact on customer satisfaction.

Research gaps not addressed in the literature are that Ishikawa did not expand on the use of the seven tools outside of Manufacturing and their use in other industries and functions. There is also no studies or elaboration on how the 95% can be broken down and quantified in terms of each tool's contribution to the overall problem-solving effort. Ishikawa is not clear about the benefits and CSF's to utilizing the tools. The application of the tools and their use can be challenging, depending on the level of training, and understanding of the tools within an organization. The authors hope to address these gaps in this study.

In this study, the authors are carrying out research to establish how widespread the use of the 7 QC tools is, where the tools are utilised and in what functions. The authors are asking the following research questions:

1. Does Ishikawa's original statement that the 7 QC tools solve 95% of quality related problems apply to manufacturing and service sectors in the same manner?
2. What is the sector wise frequency of QC tool usage?
3. What are the benefits, challenges, and critical Success factors for the application of the seven QC tools?

3.0 Methodology

The authors utilised an online survey for data collection targeted at senior quality professionals working in operational excellence including, quality consultants, quality directors, quality engineers, quality managers and quality supervisors working in both manufacturing and service sectors. The advantages of online surveys include speed and reach, ease, cost, flexibility, and automation (Ball, 2019). Therefore, the survey method was one of the most appropriate methods for this type of study, as it allows the collection of a huge amount of information from respondents in a short time (Couper and Miller, 2008). The survey instrument developed for this study was divided into two sections. The first one to acquire general information about the respondents and their organizations. A check question was used; have you been trained on the seven tools of quality? (If NOT, please do not continue!). The second section was devoted to eliciting information about various aspects on the use of the original seven tools of quality control. The purposive sampling was used to recruit quality professionals in this study. In this study we used a modified Dillman approach (Dillman *et al.*, 2014) with a multipronged strategy which was done to maximise the response (King *et al*., 2014). The Dillman approach offers explicit guidelines for the conduct of survey research, which are designed to increase survey response rates (Dillman *et al*., 2009) and the multipronged strategy (King *et al*., 2014) allowed for increased contact with potential participants who were quality professionals (Stokes *et al.*, 2019). Through various modalities supported in LinkedIn the authors had set up an initial public post outlining the objectives of the study. Subsequently, we contacted quality professionals from LinkedIn to participate in this study through emails and the LinkedIn personal messaging system. The professionals who agreed to the study were sent the questionnaire. Additionally, as quality professionals are busy, unnecessary long questionnaires may not be attractive to them. Therefore, the short nature of the questionnaire was designed which scaffolds respondents in answering the survey in a short period. A pilot study was conducted during the survey instrument development process. The online survey protocol was first piloted (Boynton and Greenhalgh, 2004) with 10 experts. The five experts who participated in the online survey protocol was academics who have published more than five articles on quality management. The other five experts were senior quality management professionals who have more than 10 years' experience in implementing quality management in their organizations. An equal number of academicians and

industry experts were considered to cover both theoretical and practical aspects of 7 quality tools. The purpose of piloting the survey questionnaire was to validate the instrument and ensure that the questions aligned with the research questions set by the researchers (Couper and Miller, 2008). The comments and feedback from the pilot study were subsequently used to review the survey questions and make the questions more readable and relevant to the research. Most of the comments were positive and hence the survey questionnaire was deemed suitable for research.

The revised online survey link was sent out to 400 subject matter experts who are working in their respective organisations in roles such as quality professionals (Director of Quality, Operational Excellence Professional, Quality Engineer, Quality Supervisor, Senior Quality Manager etc). The contacts were obtained through LinkedIn and each of the respondents was contacted through email. A similar methodology was used by the authors in previous studies (Antony *et al*., 2019; Antony *et al.,* 2020). The authors used three criteria in the selection of such subject matter expert; i) all respondents should be working in their role as quality professionals, (ii) should be working in an organisation as a Director of Quality, Operational Excellence Professional, Quality Engineer, Quality Supervisor, Senior Quality Manager or in similar roles. (iii) Should be working in manufacturing or service sector.

Setting such criteria will enable the authors to glean knowledge from a high calibre of experts from the survey participants, who are responsible for quality in their respective organisations.

A total of 97 valid responses were collated over 18 weeks, yielding a response rate of 24.25%. Easterby-Smith *et al.*, (2012) argue that a 20% survey response rate is widely considered to be sufficient. The sample characteristics are given in table 1.

Table 1: Sample Characteristics

Row Labels	**Female**	**Male**	**Grand Total**
Operational Excellence professional	11	24	35
Quality Consultant	1	4	5
Quality Director	1	2	3
Quality Engineer	8	18	26
Quality Manager	3	3	6
Quality Supervisor	4	18	22
Grand Total	**28**	**69**	**97**

4.0 Key Findings

The respondents were asked a question on whether they had been trained on the seven tools of quality. As shown in Figure 1. 80.41% of the respondents were trained in the seven basic and original quality control tools. The seven basic quality control tools are among the most useful, and popular used tools in many organizations today and therefore, most of the quality professionals were trained in them.

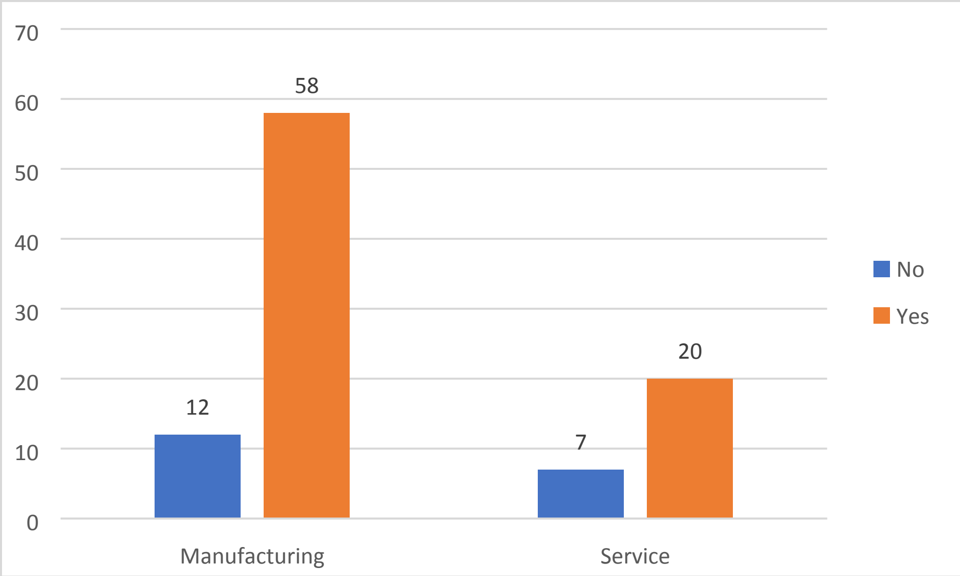

Figure 1: Percentage of respondents trained in seven quality tools

The respondents were asked what percentage of quality problems in your current business can be tackled using the 7 basic tools of quality promoted by Dr Ishikawa and the results are elucidated in Table 2.

Table 2: Percentage of quality problems in your current business can be tackled using the 7 basic tools of quality promoted by Dr Ishikawa

Row Labels	**Less than 50%**	**50 to 80%**	**Above 80%**	**Grand Total**
Manufacturing	*19*	*26*	*13*	*58*
Above five years	14	17	8	39
Less than five years	5	9	5	19
Service	*11*	*6*	*3*	*20*
Above five years	7	1	1	9
Less than five years	4	5	2	11
Grand Total	*30*	*32*	*16*	*78*

The analysis of data from the study suggests that in both manufacturing and service sectors that about 20% of respondents felt that these basic tools can solve above 80% of quality related problems in their businesses. This is quite different from the findings reported and originally claimed by Dr Ishikawa (Ishikawa, 1982). It is quite evident that modern quality problems need much more than the seven basic tools of QC. Traditional quality management practices and methods have not absorbed changes in product development stages, cycle time compression and employee effort to match demand and customer expectations (Gunasekaran *et al*., 2019). Besides, digitalisation of the organization creates new opportunities for organizations to incorporate technological advances to arrive at new optimums in operational excellence, performance and innovation (Sony *et al*., 2020). Therefore, there is an urgent need to revisit the role and contribution of seven basic tools to solve modern quality problems of the organization.

To understand how the quality professionals are using the seven quality tools in manufacturing, and service sectors, the respondents were asked the frequency of tool usage. The results are expounded in Table 3.

Table 3: Frequency of tool usage other functions Sector Wise

		Sales	Production	Supply Chain & Logistic	Customer Care	Finance	NPI&NPD (Product Development)	Admin	IT	Marketing	HR	R&D	**Total**
Manufacturing													
	Check Sheet	6	30	13	9	1	9	5	2	3	5	8	91
	Scatter Diagram	4	20	5	4	3	6	2	1	5	1	4	55
	Histogram	10	36	11	10	3	13	6	2	7	4	7	109
	Pareto Analysis	16	39	14	13	6	13	8	5	12	6	13	145
	Cause Effect Diagram	11	44	12	13	4	12	9	3	6	7	14	135
	Stratification	6	20	3	10	4	9	6	4	5	5	3	75
	Control Charts	7	35	8	6	1	12	5	1	7	4	4	90
Service													
	Check Sheet	6	9	2	1	3	3	5	3	3	1	1	37
	Scatter Diagram	5	5	2	2	1	2	5	4	5	1	3	35
	Histogram	9	8	5	3	5	2	5	4	6	2	4	53
	Pareto Analysis	8	7	6	4	6	1	7	8	3	4	2	56
	Cause Effect Diagram	6	13	5	3	3	4	6	4	5	3	3	55
	Stratification	8	6	3	1	3	2	2	1	2	2	2	32
	Control Charts	3	10	4	2	2	2	6	4	2	1	3	39
Total		105	282	93	81	45	90	77	46	71	46	71	1007

It was found that in both manufacturing and service sectors, the most frequently used 7 quality tools were: *Pareto analysis, histogram, and cause-effect diagram.* Pareto analysis is used for identification of quality problems. Cause effect diagram can be used for both identification & analysis of quality problems, whereas the histogram is used for the analysis of quality problems (Kerzner, 2017). Thus, in both sectors quality professionals are using these three tools for identification and analysis of quality problems. However, the frequency of usage of all the tools is higher in production as compared to all other business functions. This is understandable as seven quality tools were traditionally developed in production or manufacturing functions. Table 4 also shows that the least frequently used tools in both manufacturing and service sectors were: scatter diagram and stratification.

Table 4: Tool usage in both sectors	
Tools	**Total Frequency of usage**
Scatter Diagram	90
Stratification	107
Check Sheet	128
Control Charts	129
Histogram	162
Cause Effect Diagram	190
Pareto Analysis	201

In the literature, some authors have replaced Ishikawa's stratification with either a flowchart or brainstorming or even a run chart (Soković *et al.*, 2009; Duffy, 2013). Stratification is defined as the act of sorting data, people, and objects into distinct groups or layers. It is a tool used in combination with other data analysis tools. When data from a variety of sources or categories have been lumped together, the meaning of the data can be difficult to see (Tague, 2005). Typical stratification groups used for quality control purposes include:

- *Who – the people involved with the problem? For example, which operator or crew was working at the time*
- *What – machines, products, raw materials, or any other objects relevant to the problem*
- *Where – a process area, physical location, or a location on a machine or product*
- *When – time of day, day of the week, shift, or process step when the problem occurs*

The respondents were further asked to determine the fundamental benefits of the seven tools based on their knowledge and experience. This question was specifically targeted to capture the perception of benefits of the seven basic quality control tools from the participants' experience. A frequency analysis was conducted sector-wise and is depicted in table 5. In addition, Pareto chart is drawn and is depicted in Figures 1 and 2, respectively. The top five benefits of the seven basic QC tools in manufacturing were: helping people to define, measure and analyse the problem areas or even prioritize them; developing potential solutions in problem solving exercises, reducing the costs of poor quality in the form of scarp, rework, repair etc; providing some form of structure to the problem-solving efforts and determining the root cause of the problem at hand. The top five benefits of the seven basic QC tools in service sector were: helping people to define, measure and analyse the problem areas or even prioritize them; providing some form of structure to the problem-solving efforts; helping the organisation with continuous improvement projects; determining the root cause of the problem at hand and improving the consistency of service performance through variability reduction in service processes. It was quite surprising to observe that the application of these powerful problem-solving tools does not foster teamwork and getting everyone involved did not appear in the top benefits list of our study.

Table 5: Sector-wise Benefits of Seven Quality tools

Manufacturing	**Code**	**Frequency**
Help problem definition, measurement, and analysis	I	37
Aid problem solving	A	31
Reduces cost of poor quality	N	31
Provide structure to problem solving	M	30
Helps determine the “true” root cause	J	29
Aids in continuous improvement	C	27
Reduces variation and improves quality	O	24
Help improve product/service quality	H	19
Aids implementation of Six Sigma	B	12
Encourages teamwork	D	12
Visibility of performance	Q	12
Facilitates collection of data and presentation of data	F	10
Helps identify areas of improvement	K	10
Enhances customer satisfaction through improve product quality	E	7
Gets everybody involved	G	7
Helps suggest and realise areas of improvement	L	4
Suitable for individuals with little formal statistical training	P	3
Service	**Code**	**Frequency**
Help problem definition, measurement, and analysis	I	16
Provide structure to problem solving	M	13
Aids in continuous improvement	C	10
Helps determine the “true” root cause	J	10
Reduces variation and improves quality	O	8
Visibility of performance	Q	7
Helps suggest and realise areas of improvement	L	5
Reduces cost of poor quality	N	5
Aids implementation of Six Sigma	B	4
Help improve product/service quality	H	4
Helps identify areas of improvement	K	4
Aid problem solving	A	3
Gets everybody involved	G	3
Facilitates collection of data and presentation of data	F	2
Encourages teamwork	D	1
Enhances customer satisfaction through improve product quality	E	1
Suitable for individuals with little formal statistical training	P	1

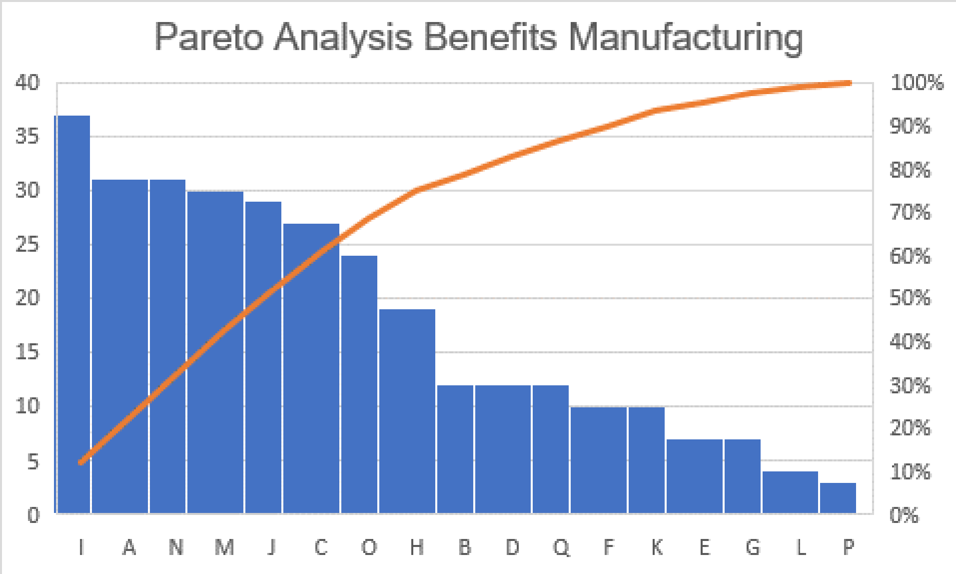

Figure 1: Pareto Analysis of benefits of using quality tools in Manufacturing sector

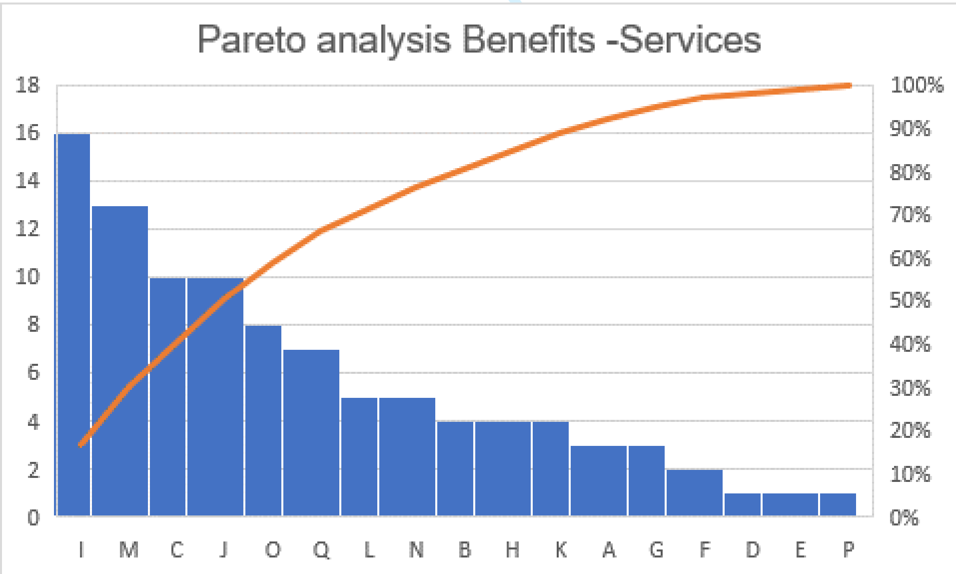

Figure 2: Pareto Analysis of benefits of using quality tools in Service sector

One of the research questions was to evaluate the challenges in the implementation of the basic tools of QC. Table 6 presents the key findings on challenges in the use of the basic seven tools of quality control. The top five fundamental challenges in the use of seven QC tools in the manufacturing sector include: lack of management support and commitment, lack of training provided to employees in the application of these tools, poor data collection methods with no planning behind, lack of understanding of the role of the seven QC tools (i.e., when, where and why they should be applied and how) and lack of education on the application of tools and their benefits across the entire organisation. The top five fundamental challenges in the use of seven QC tools in the service sector include: lack of knowledge on what the tools can do in process and quality improvement scenarios, lack of understanding of the benefits of the tools, lack of training provided to employees in the application of these tools, lack of understanding of the role of the seven QC tools (i.e., when, where and why they should be applied and how) and poor data collection methods with no planning behind. It was interesting to note that the challenges in both sectors were quite similar.

Table 6: Sector-wise challenges for using seven quality tools

Manufacturing	**Code**	**Frequency**
Lack of management support	E	30
Lack of Training	G	27
Poor data collections methods	O	25
Lack of understanding of each tool and its application	I	21
Lack of education on the use of tools across entire organisation	A	19
Lack of knowledge about the tools	D	19
Lack of statistical knowledge	B	18
Lack of understanding of benefits of the tools	H	18
Not using the right tools at the right time	L	18
The tools can be seen only for “manufacturing” or “production” departments only	Q	16
Application of tools is an additional responsibility and I have no time	C	15
Poor/Bad organisational culture	P	15
Lack of teamwork	F	13
Poor communication	N	13
No motivation or drive to apply the tools	J	10
Poor attitude towards quality improvement	M	10
No need for the use of tools as we are different	K	6
Service	**Code**	**Frequency**
Lack of knowledge about the tools	D	11
Lack of understanding of the benefits of the tools	H	11
Lack of Training	G	9
Lack of understanding of each tool and its application	I	8
Poor data collections methods	O	8
Lack of education on use of tools across entire organisation	A	7
Lack of management support	E	7
Not using the right tools at the right time	L	6
The tools can be seen only for “manufacturing” or “production” departments only	Q	5
Lack of statistical knowledge	B	4
Lack of teamwork	F	4
Poor communication	N	4
Poor/Bad organisational culture	P	4
No motivation or drive to apply the tools	J	2
Application of tools is an additional responsibility and I have no time	C	1

Poor attitude towards quality improvement	M	1
No need for the use of tools as we are different	K	0

The last part of the research was to understand the critical factors required for the successful application and implementation of the seven basic tools of QC. The top five critical success factors in manufacturing sector were: uncompromising management commitment and support, use of tools within the existing CI initiatives, identifying and creating the opportunities for the application of tools in the workplace through continuous improvement projects, the systematic and disciplined approach to problem solving and employee participation and involvement in problem-solving sessions. The top five critical success factors in service sector were: communicating and sharing the success stories and benefits from the application of tools across the organisation, company-wide training on the use of tools in problem solving exercises, uncompromising management commitment and support, communicating the benefits of tools and developing a culture of continuous improvement mind-set through the effective utilization and deployment of tools and use of tools within the existing CI initiatives.

Table 7: Sector wise critical success factors for tool usage

Manufacturing	**Code**	**Frequency**
Management support	F	30
Having a continuous improvement program	E	29
Opportunity to use the tools	H	23
The seven tools provide a systematic and disciplined approach instead of using trial and error approach to problem solving	A	22
Opportunity to participate in problem solving sessions or events	G	21
Creating the Sense of urgency by the senior management team for the use of tools in solving problems	D	18
Communicating the benefits of tools across all levels of the organisation and developing a culture based on this	B	17
Sharing success stories and benefits	J	17
Recognition and Reward at the team level for the success on the application of tools	I	16
Company-wide training	C	14
Service	**Code**	**Frequency**
Sharing success stories and benefits	J	13
Company-wide training	C	10
Management support	F	10
Communicating the benefits of tools across all levels of the organisation and developing a culture based on this	B	9
Having a continuous improvement program	E	9

Recognition and Reward at the team level for the success on the application of tools	I	6
Opportunity to use the tools	H	5
The seven tools provide a systematic and disciplined approach instead of using trial and error approach to problem solving	A	4
Creating the Sense of urgency by the senior management team for the use of tools in solving problems	D	3
Opportunity to participate in problem solving sessions or events	G	3

Incorrect application of seven quality tools will not result in the desired outcomes. To capture the respondent's perception of incorrect tool usage the respondents were asked "How often have you utilised the "wrong" or "incorrect" QC tool in a problem-solving situation". The question was personalised by adding "you" and hence there is a tendency for socially desirable responding (Paulhus, 1984). Therefore, in this research, personal identification details were never asked; besides, this question was not made a compulsory question so that respondents do not feel threatened and answer it incorrectly in a socially desirable manner. In the manufacturing sector, 38.2% and in services 36.8% of respondents felt that they have used the quality tools incorrectly.

Table 8: Incorrect quality tool usage

Row Labels	**Manufacturing**	**Service**	**Grand Total**
Less than 20%	21	7	28
Between 20% and 39%	16	5	21
Between 40% to 59%	8	5	13
Between 60% to 79%	10	2	12
Grand Total	**55**	**19**	**74**

5.0 Discussion, Implications and Limitations

The original seven basic tools of QC propagated by Dr Kaoru Ishikawa has been around for nearly 4 decades. Although 80% of quality professionals have been trained in these powerful tools for problem solving, the authors argue that all quality professionals must be trained on these tools irrespective of the nature and size of the organisation. Ishikawa's work in the late 1960s and 70's showed that more than 90% of work-related problems can be tackled using the seven basic tools of QC. However, the authors found the results of this study significantly different from his claim in the 1980s through his books (Ishikawa, 1982; Ishikawa 1985; Ishikawa, 1990). The authors findings from the study suggest that less than 25% of quality problems can be tackled using the original seven basic tools of QC in both manufacturing and service sectors. This shows that perhaps it is time to revisit the role and contribution of the seven basic tools of quality control for tackling quality problems in organisations today.

The most frequently used tools among the seven basic tools of QC in both manufacturing and service sector were: Pareto Analysis, Histograms and Cause and Effect analysis. The least frequently used tools were: Scatter diagrams and Stratification. Further analysis of data has revealed that the seven basic tools were least utilised in the HR, IT and Finance functions. The common benefits from the use of seven basic tools of QC in both manufacturing and service sectors include: helping people to define, measure and analyse the problem areas or even prioritize them; providing some form of structure to the problem-solving efforts; helping the organisation with continuous improvement projects and determining the root cause of the problem under investigation. Similarly, the common challenges in the use of seven basic tools of QC include: lack of understanding of the benefits of the tools, lack of training provided to employees in the application of these tools, lack of understanding of the role of the seven QC tools (i.e., when, where and why they should be applied and how), poor data collection methods with no planning and lack of management commitment and support. Critical Success Factors (CSFs) are the essential ingredients which are required for making the application of tools successful in any organisational setting. The authors found that only two among the top five CSFs in manufacturing and service organisations were similar according to the analysis of the survey data. These were uncompromising management support and their involvement in the application of tools for solving quality related problems and having a continuous improvement program or initiative in the organisation which provides an opportunity for everyone to have a toolkit with the tools they need to tackle the problems at the workplace. It was quite surprising to observe that company-wide training was the least critical success factor in the perspectives of participants in Brazilian manufacturing organisations and moreover reward and recognition system at the team level was not considered to be important in the manufacturing companies. Similarly, in the service sector, identifying and creating the opportunities for the application of tools in the workplace through continuous improvement projects was observed to be non-critical factor. This could be attributed to the lack of quality mind-set, lack of sense of urgency and poor organisational culture set by the senior leaders in such organisations. Finally, one of the most interesting findings of the research was that more than quality professionals have been applying incorrect tools right first time in both manufacturing and service sectors by more than 35%.

The next phase of the research is to identify the root causes for the incorrect application of the seven basic tools of QC which have been around for more than four decades (Ishikawa, 1976).

This research shares several managerial implications. First and foremost, the authors are questioning the original data derived from the work of Ishikawa in the 1970s and its validity today in the organisations. If more than 90% of work-related problems cannot be tackled using the original seven tools of QC, then what other relevant tools need to be brought into the toolkit in problem solving scenarios in both manufacturing and service organisations. Secondly, Ishikawa in his work never showed how the seven tools can be useful in all business functions in an organisation such as IT, Finance, HR, Marketing, Sales, and Supply Chain. This research addresses this gap showing where the seven tools of QC have been applied the most and where they have been applied the least. This would help senior managers to identify problem areas across various functions for the deployment of these powerful tools in problem solving exercises. It has been found that more than 35% of basic tools of QC have been applied incorrectly and this would cost organisations a huge amount of money. The CSFs identified in this study can be used as an invaluable guide for senior managers to take them into account during the application of these powerful tools in any problem-solving scenarios.

Finally, this study has some limitations that must be noted. Firstly, the low response rate could possibly limit the generalizability of the findings and robustness of the conclusions. Secondly, data were mostly obtained from a single respondent in each organization from South American companies. Perhaps multiple samples from each firm could have given less biased responses and greater consistency. Thirdly, it is worth testing and comparing the validity of the results in companies operating in different countries worldwide. The authors are keen to investigate and learn about the perceived differences in the findings of the study with different countries and varied organisational cultures. Finally, the authors are planning to pursue more in-depth exploratory research in the form of semi-structured interviews or focus groups involving a number of leading quality practitioners in the field to obtain further insights into the topic of interest.

6.0 **Conclusion and Directions for Further Research**

According to the results presented in this study, there is evidence to challenge Dr. Ishikawa's original statement that the 7 QC tools solve 95% of quality related problems in both manufacturing and service sectors in the same manner (research question 1). The authors findings from the study suggest that less than 25% of quality problems can be tackled using the original seven basic tools of QC in both manufacturing and service sectors. This shows that perhaps it is time to revisit the role and contribution of the seven basic tools of quality control for tackling quality problems in organisations today.

Considering the sector wise frequency of QC tool usage (research question 2), this study pointed to the conclusion that Pareto Analysis, Histograms and Cause and Effect analysis are the most used tools in both manufacturing and service sectors. The least used tools are Scatter diagrams and Stratification.

The common benefits from the use of seven basic tools of QC in both the manufacturing and service sectors include: helping people to define, measure and analyse the problem areas or even prioritize them; providing some form of structure to the problem-solving efforts; helping the organisation with continuous improvement projects and determining the root cause of the problem under investigation.

The top five Critical Success Factors (research question 3) to properly apply Dr. Ishikawa's 7 QC tools identified in this research work for the manufacturing sector were: (1) management support; (2) having a continuous improvement program; (3) opportunity to use the tools; (4) systematic and disciplined approach avoiding trial and error for problem solving and (5) opportunity to participate in problem solving sessions or events.

The top five Critical Success Factors for service sector were: (1) sharing success stories and benefits; (2) company-wide training; (3) management support; (4) communicating the benefits of tools across all levels of the organisation developing a culture based on this (5) having a continuous improvement program

In terms of further research, it is important to reinforce that this study was focused on practitioners from South American companies. So, it is relevant to consider expanding this survey to professionals working in different continents. It would potentially increase the generalizability of the results. As mentioned previously, the authors will develop a more detailed exploratory research in the form of semi-structured interviews or focus groups with different leading quality practitioners in the field.

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