An empirical study into Ishikawa's basic tools of QC in European organisations

An Empirical Study into Ishikawa's Basic Tools of QC in European Organisations

Jiju Antony[1], Olivia McDermott[2], Michael Sony[3]

[1] Heriot-Watt University, Scotland, j.antony@hw.ac.uk

[2] National University of Ireland, Galway, Ireland, Olivia.McDermott@nuigalway.ie

[3] Namibia University of Science and Technology, Namibia, emailofsony@gmail.com

Abstract: The purpose of this European study is to investigate the statement of Dr Ishikawa that "95% of problems in processes can be solved using the 7 Quality Control (QC) tools". An online survey instrument was developed, disseminated, and responded to by 228 senior quality professionals from across Europe. The main finding of this study is that just 15% of participants perceived that the seven tools of QC could solve above 90% of quality problems, and 40% had utilised the incorrect tools when problem-solving. Pareto analysis was the most widely used tool across European organisations, while the least used tools are Scatter diagrams and Stratification. The 7 QC's tools were widely utilised in Production or Manufacturing areas but least applied in IT, Administration and Finance functions. The common benefits from using the seven basic tools of QC in all sectors include: providing structure to problem-solving efforts, aids problem solving and helps in problem definition, measurement, and analysis. This work presents a list of critical success factors (CSF's) required for the proper application of the 7 QC tools, including having management support, having a continuous improvement (CI) program and having a systematic and disciplined approach to problem-solving. This study is the first European research focused on investigating Dr Ishikawa's statement: "95% of problems in processes can be solved using the 7 Quality Control tools". The findings further facilitate an important first step towards understanding the applicability, benefits, and CSFs to utilising these tools in organisations across functions, sectors and globally.

Key Words: Quality, Quality Control, Tools, Quality Management, Quality Improvement, Surveys

1 Introduction

Increased globalisation and demand for good quality products and services in an expedited manner has increased pressure on organisations to remain profitable. Within the area of quality management, many tools and techniques are utilised to aid problem-solving within a defined framework and solve quality problems. Quality professionals utilise a set of tools and techniques to help root cause problems and implement corrective actions in organisations (Spring *et al.*, 1998; Revelle, 2012). Dr Ishikawa is known for his work on companywide quality control, quality circles, and education and training in the use of continuous improvement. He stated that seven basic tools were vital for problem-solving. These include Check Sheets, Histograms, Pareto Analysis, Cause & Effect Diagrams, Control Charts, Scatter Diagrams, and Stratification (Ishikawa, 1976).

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 did not elaborate on this statement.

This research challenges Ishikawa's original statement that 95% of problems can be solved using the seven quality control tools. The utilisation, effectiveness, and application of the seven quality control tools in other functions or support departments outside manufacturing environments are also unclear. This research will explore the extent of the use of the 7 QC tools in different business functions outside of production and manufacturing. The study 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. Finally, the research will ascertain how often QA professionals utilise the wrong or incorrect tool when problem-solving.

2 Literature Review

The seven QC tools developed by Kaoru Ishikawa are a set of graphical techniques identified as being very important and vital in problem-solving and helping ascertain root cause for quality problems (Kiran, 2017). The tools are basic because individuals with little or no training in statistics can utilise the tools to solve most quality problems. Techniques are a collection of tools and facilitate positive change and improvements and, when used together, help implement change (McQuater *et al.*, 1995; Ishikawa, 1985).

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 (Antony *et al.*, 2021). Quality gurus including Juran (1988) and Ishikawa (1976) as well as other authors (Al-Saedi, Pasławski and Nowotarski, 2019; Bamford and Greatbanks, 2005; Mach and Guáqueta, 2001; Tennant, 2001) have written about the application of the basic seven QC tools and other techniques in various depths.

Quality tools have many benefits for displaying data visually, helping identify and prioritise areas that cause the most problems; demonstrating relationships between variables; establishing root cause, and showing the distribution of data (Lamb and Dale, 1994; Dale and Shaw, 1991; Bergman and Klefsjo, 1994) The main goals of the quality tools are to increase communication and teamwork to aid the detection of problems ((Dale and Shaw, 1991; Marsh, 1996)

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 also stated that "95% of problems in processes can be solved by the use of the 7 QC tools" and that in very complicated processes, advanced techniques and computers are a requirement. He did state, however, that most defectives 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 utilising the 7 QC tools (Ishikawa, 1985).

Bamford and Greatbanks (2005) report that the use and exploitation of the 7QC tools and techniques is not as widespread and effective as might be expected due to insufficient training in the use and application of these approaches. Some challenges have included the opinion that the majority of the tools are incapable of dealing with non-numerical data (He et al.,1996).

Some CSF's for utilising tools include having management support and commitment, providing training, a requirement and a need to utilise tools and a culture of collaboration and teamwork (McQuater *et al.*, 1995) Understanding the goal of utilising a specific type of tool or technique, its pre-requisites, benefits, and obstacles in implementing is critical to success and use (Spring *et al.*, 1998).

There are many benefits of problem-solving to the financial bottom line and profits. Utilising the wrong tool can lead to the incorrect root cause and corrective action and having to go and restart the problem-solving process again (Hagemeyer, Gershenson and Johnson, 2006; Bunney and Dale, 1997).

González-Benito, Martínez-Lorente and Dale (2003) discussed the importance of utilising a combination of tools rather than a single tool as best to solve issues and provide solutions. When utilising QC tools, mistakes can occur, including using the wrong quality tool or not knowing how to use the tools (Hagemeyer, Gershenson and Johnson, 2006).

The 7 QC tools put forward by Dr Ishikawa are valuable tools for Quality management and implementing process improvements. However, he did not expand on the use of the seven tools outside of Manufacturing environments and their use in other functions. The benefits and CSF's to implementing and utilising the tools are obvious. Applying the 7 QC tools and utilisation of the tools, however, can result in challenges.

3 Methodology

The authors utilised an online survey for data collection targeted at European senior quality professionals working in operational excellence including, quality consultants, quality directors, quality engineers, quality managers and quality supervisors working across all functions and sectors. The advantages of online surveys include speed and reach, ease of use, inexpensive, flexibility, and automation (Schaefer & Dillman, 1998; Lefever et al., 2007). Quantitative online survey methods are one of the most appropriate methods for this type of study. Web surveys guarantee a relatively short time frame for collecting responses, are flexible and are time and cost-saving (Evans & Mathur, 2005). The survey was designed to ascertain the level of training that the respondents had in the seven tools of quality and establish information about various aspects of the use of the original seven tools of quality control. The authors contacted quality professionals from LinkedIn to participate in this study through emails and the LinkedIn personal messaging system in advance before sending them the survey. Before distributing the survey, prior contact with potential respondents helped gain respondent commitment to questionnaire completion prior to distribution (Flynn *et al.*, 1997). The questionnaire was designed to be short as, generally, quality professionals are busy and do not have time for long surveys. The online survey protocol was first piloted with ten experts as piloting is recommended best practice (Puleo et al., 2002; Boynton & Greenhalgh, 2004). The purpose of the piloting exercise was to identify those questions that needed improvement from a practical standpoint and ensure that nothing had been omitted by the researchers (Forza, 2002). However, most of the comments were positive, and hence the survey questionnaire was deemed suitable to send out to respondents.

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 (Hundal *et al.*, 2021; Antony and Sony, 2019; Antony *et al.*, 2021). The authors used three criteria in the selection of such subject matter experts; 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. A total of 228 valid responses were collated over 18 weeks, yielding a response rate of 60%. Multiple samples were taken from some organisations, and this gave less biased answers and greater consistency.

4 Results

The first question asked of respondent's was, "*Have you been trained in the seven tools of quality?*". 84% of respondents indicated that they had been trained in the seven quality tools. This was not surprising because the authors specifically targeted quality professionals for this study and that the seven tools are part of many traditional quality training programs.

The respondents were asked what percentage of quality problems in their current business can be tackled using the 7 basic tools of quality promoted by Dr Ishikawa. The results are elucidated in Table 1.

Table 1 - Percentage of quality problems in your current business can be tackled using the 7 basic tools of quality promoted by Dr Ishikawa.

Europe	**<20%**	**21-30%**	**31-40%**	**41-50%**	**51-60%**	**61-70%**	**71-80%**	**81-90%**	**>90%**
No of respondents	*16*	*14*	*24*	*14*	*21*	*25*	*30*	*24*	*29*
% of respondents	8%	7%	12%	7%	11%	13%	15%	12%	15%

The analysis of data from the study suggests that just 15% of respondents felt that these basic tools could solve above 90% of business problems across European organisations. This contradicted Dr Ishikawa's claim (Ishikawa, 1982) that the tools solved 95% of problems. It is evident that in modern-day organisations that the seven QC tools are not what is required to solve quality problems. The tools have usefulness, but a more comprehensive toolset is required. The advent of Quality 4.0 and increased digitalisation of organisations creates new opportunities for organisations to incorporate technology into their operational excellence and quality management programs. Therefore, there is an urgent need to revisit the role and contribution of seven basic tools to solve modern quality management problems.

To understand how prevalent the seven QC tools usage is in Europe amongst quality professionals, the respondents were asked about their frequency of using the seven tools. The results are demonstrated in Table 2. It was found that across Europe, the most frequently used 7 quality tools were: Pareto analysis, histograms, and cause & effect diagrams which are used for identification and analysis of quality problems. Table 2 also shows that the tools in order of utilisation and preference. The least utilised tools were scatter diagrams and Stratification.

Table 2 – Frequency of usage of the 7 basic tools of quality

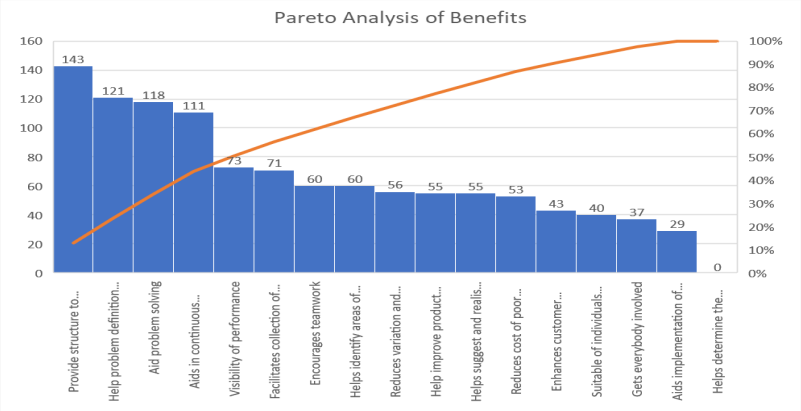
Tools	**Total Frequency of usage**
Stratification	14
Scatter Diagram	43
Check Sheet	108
Control Charts	129
Histogram	133
Cause & Effect Diagram	163
Pareto Analysis	173

The respondents were asked, "*In what functions within your organisations are the 7 QC tools utilised?"* as demonstrated in Table 3. However, the frequency of usage of all of the tools is higher in production or manufacturing functions as compared to all other business functions. As quality management and tools and techniques originated within manufacturing environments, this is not surprising. The tools were utilised least frequently within the HR, IT and Administration functions.

Table 3 -Proportion of tool usage across different functions of the organisation

	Sales	Production	Supply Chain & Logistic	Customer Care	Finance	NPI & NPD (Product Development)	Admin	IT	Marketing	HR	R&D
Europe											
Check Sheet	4.0%	28.0%	10.0%	8.0%	5.0%	14.0%	6.0%	4.0%	4.0%	5.0%	12.0%
Scatter Diagram	5.0%	20.0%	8.0%	6.0%	6.0%	21.0%	2.0%	4.0%	6.0%	1.0%	21.0%
Histogram	10.0%	19.0%	9.0%	7.0%	7.0%	12.0%	5.0%	4.0%	7.0%	5.0%	15.0%
Pareto Analysis	10.0%	20.0%	9.0%	9.0%	7.0%	11.0%	4.0%	5.0%	8.0%	4.0%	13.0%
Cause Effect Diagram	6.0%	22.0%	8.0%	10.0%	5.0%	14.0%	5.0%	5.0%	4.0%	4.0%	17.0%
Stratification	11.0%	20.0%	8.0%	9.0%	6.0%	12.0%	3.0%	6.0%	8.0%	2.0%	15.0%
Control Charts	6.0%	30.0%	9.0%	9.0%	6.0%	11.0%	3.0%	5.0%	6.0%	12.0%	3.0%

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 benefits of the seven basic quality control tools from the participants' experience. The top three benefits of the seven basic QC tools in European organisations were 1) providing some form of structure to the problem-solving efforts and determining the root cause of the problem at hand 2) helping people to define, measure and analyse the problem areas or even prioritise them and 3) aiding problem solving (see Figure 1).

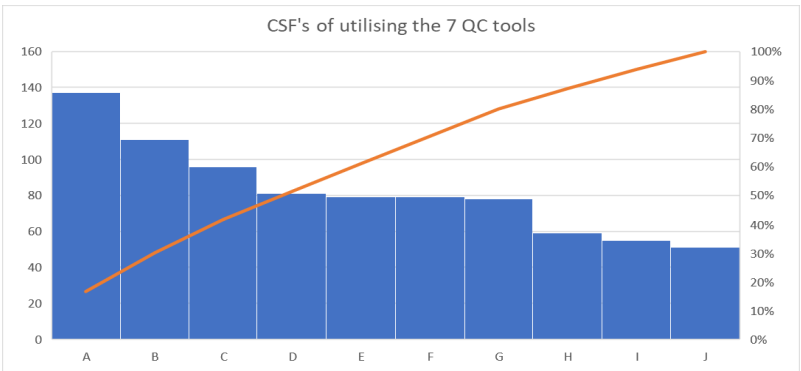


Benefits	Code
Provide structure to problem solving	A
Help problem definition, measurement, and analysis	B
Aid problem solving	C
Aids in continuous improvement	D
Visibility of performance	E
Facilitates collection of data and presentation of data	F
Encourages teamwork	G
Helps identify areas of improvement	H
Reduces variation and improves quality	I
Help improve product/service quality	J
Helps suggest and realise areas of improvement	K
Reduces cost of poor quality	L
Enhances customer satisfaction through improve product quality	M
Suitable of individuals with little formal statistical training	N
Gets everybody involved	O
Aids implementation of Six Sigma	P
Helps determine the “true” root cause	Q

Figure 1: Pareto Analysis of benefits of using the 7 quality tools and legend listing benefits.

One of the subsequent research questions was to evaluate the challenges in the implementation of the basic tools of QC. The top five challenges in the use of the seven QC tools in Europe include lack of knowledge about the tools, poor data collection methods, lack of training, lack of education on the tools and lack of management support.

The QA professionals were also asked, “*What CSFs were required for the successful application and implementation of the seven basic tools of QC?*”. The top five critical success factors as outlined in Figure 2 were: management support, having a CI program, providing a systematic and disciplined approach, having opportunities to use the tools and opportunities to participate in problem-solving sessions.



Europe	Frequency
Management support	A
Having a CI program	B
Provide a systematic and disciplined approach	C
Opportunity to use the tools	D
Opportunity to participate in problem solving sessions	E
Communicating the benefits of tools across the organisation	F
Company-wide training	G
Recognition and Reward at the team level	H
Sharing success stories and benefits	I
Creating the Sense of urgency by the senior management team	J

Figure 2 -CSFs of utilising the 7 QC tools Pareto & Legend.

Another question asked was, "*How often have you utilised the wrong or incorrect tool when problem-solving?* The respondents indicated that 40% had used incorrect tools, while 60% felt they had used quality tools incorrectly. This demonstrates how lack of understanding and misapplication of tools and training in using the tools can be costly for an organisation.

5 Discussion, Implications and Limitations

Dr Kaoru Ishikawa proposed his seven quality tools over 40 years ago. Although 100% of quality professionals have stated that they have been trained in these tools for problem-solving, many still find challenges in utilising and applying the tools. Application of the tools is also inconsistent with some tools utilised more than others and, in some functions, more than in others. Also, the tools are still very confined to Manufacturing organisations and functions despite the focus on the customer and quality across all departments and units within organisations.

Ishikawa's work in the late 1960s and '70s stated that more than 90% of work-related problems can be tackled using the seven basic tools of QC (Ishikawa, 1982; Ishikawa, 1985; Ishikawa, 1990). The author's findings from the study suggest that just 15% of respondents belied that >90% of quality problems can be tackled using the original seven basic tools of QC in European organisations. As the seven tools are included in almost every type of quality management training program or curriculum, it is time to address how the tools are being taught and what other tools should be utilised going forward.

The most frequently used tools among the seven basic QC tools 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 Administration functions. The common benefits from the use of seven basic tools of QC include aids problem solving, providing some form of structure to the problem-solving efforts and helping problem definition, measurement and analysis. Similarly, the common challenges in using seven basic tools of QC include lack of knowledge about the tools, poor data collection methods, lack of training provided to employees in the application of these tools. The Critical Success Factors (CSFs) are having management support, having a continuous improvement program and having a systematic and disciplined approach. Finally, one of the most interesting research findings was that 40% of quality professionals have been applying incorrect tools right first time across European organisations.

This research shares several managerial implications. This research is being carried out decades after Ishikawa's work, and it questions its validity today in modern organisations. If more than 95% of work-related problems cannot be tackled using the original seven QC tools, then quality management

educational programs and training need to cover what other relevant tools need to be brought into the toolkit in problem-solving scenarios in organisations for the future. Secondly, in his work, Ishikawa never elaborated on how the seven tools can be useful in all business functions in organisations such as IT, Finance, HR, Marketing, Sales, and Supply Chain. This research addresses whether the seven QC tools are being utilised and applied and where they have been applied the most, and where they have been applied the least. This can help senior managers identify problem areas and training opportunities across various functions to deploy these functional and easy to use tools in continuous improvement programs and problem-solving exercises. It has been found that 40% have misapplied the basic tools of QC, and this would be a costly waste of time and resources in organisations. The CSFs identified in this study can be used as a guide for senior managers to consider while applying the 7 QC tools in any problem-solving scenarios.

Finally, this study has some limitations that must be noted. The majority of the respondents were from Ireland and the UK, with a minority from France, Spain, and Germany. It would be worth increasing the survey with a high % participation across all of Europe. The authors are planning to pursue more in-depth exploratory research in the form of semi-structured interviews or focus groups involving several leading quality practitioners in the field to obtain further insights into the topic of interest.

6 Conclusions and Directions for Further Research

Based on the author's research and results presented in this study, there is evidence from Europe to challenge Dr Ishikawa's original statement that the 7 QC tools solve 95% of quality-related problems. Less than 15% of the European respondents indicated that more than 90% of the problems could be solved using the 7 QC tools. This study pointed to the conclusion that Pareto Analysis, Histograms and Cause and Effect analysis are the most used tools in European organisations, while the least used tools are Scatter diagrams and Stratification. According to European QA professionals, the top three benefits of using the seven basic QC tools include aiding problem-solving, providing structure to the problem-solving efforts, and helping problem definition, measurement, and analysis.

The top three CSF's to correctly applying the 7 QC tools identified in this research were (1) management support, (2) having a continuous improvement program, (3) having a systematic and disciplined approach for problem-solving.

In terms of further research, it is important to reinforce that this study was focused on practitioners from European companies. 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). Also, with increased digitalisation and the advent of Quality 4.0 it is important to look at what tools and techniques and skills are relevant in a quality professional training curriculum of the future.

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