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THE USE AND APPLICATION OF ISHIKAWA'S SEVEN BASIC TOOLS IN EUROPEAN ORGANISATIONS

Abstract: *The objective of this research is to explore the statement of Dr Ishikawa that "95% of process problems can be rectified using the 7 Basic tools of Quality".This qualitative study utilising interviews found that only 15% of respondents stated Ishikawas tools could help solve more than 90% of problems related to quality in an organisation, and 40% indicated that the wrong tools had been applied in situations for problem-solving. The main commonly utilise Ishikawa tools was the Pareto diagram across European organisations, while Scatter diagrams alongside the Stratification diagram were the least utilised. The main advantages to utilising the Ishikawas tools of QC in European organisations include: providing a structured approach to problem-solving and helping with solving of problems. Furthermore, this research puts forward critical success factors (CSF's) required for adequately applying Ishikawas tools, including the commitment of management, having an active program for improvement, and a dedicated methodology for problem-solving. This study is unique in Europe in focusing on investigating Ishikawa's statement: "95% of problems in processes can be solved using the 7 tools". The study results aid a critical step to ascertain where the tools are applied, the advantages and CSFs to utilising Ishikawas tools in organisations across functions, and within worldwide organisations.*

Keywords: *Quality, Quality Management, Quality Improvement, Ishikawa, 7 tools*

1. Introduction

Increased globalisation and demand for world class quality in purchased products and services in an expedited manner has increased pressure on organisations to remain profitable. Within quality management,

many types of tools and complimentary techniques are utilised to aid problem-solving within a defined framework and solve quality problems. Quality professionals utilise many types of tools in helping to root cause problems and implement corrective actions in organisations (Spring et al., 1998). Hellsten & Klefsjö (2002) have outlined how vital that the use of tools for quality improvement are within an organisation fostering a culture of organisational wide quality culture.

The keys are to decide what you want from a particular type of technique; its prerequisites, the advantages and barriers in implementation that are critical to success and use (McQuater et al., 1995).

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Ishikawa is famous for his studies and writings on company-wide control of quality, and for providing education within quality improvement. He stated that just seven very simple tools were crucial for solving of company problems. These include Check Sheets, Control Charts, Pareto Analysis, Scatter Diagrams, Cause & Effect Diagrams, Histograms and Stratification charts (Ishikawa, 1976). Furthermore, Ishikawa wrote that, "the tools, if used skilfully…. enable 95% of problems within a workplace to be solved". He elaborated that "advanced statistics are only required in around 5% of all problems". Many studies have identified the widespread utilisation of Ishikawa's tools to aid problem solving (Hellsten and Klefsjö , 2000) and as an integral component of any continuous improvement program but have been critical of the usage of these tools in utilising non-numerical data (Mizuno, 1988).

This research challenges Ishikawa's statement that 95% of problems can be solved by the utilisation of the seven basic quality control tools. The utilisation, application and effective use in other functions outside of manufacturing environments of the 7 basic QC tools is also unknown. This research paper will explore the use of the 7 Basic tools in different functions besides in just the manufacturing function. The research will also analyse the level and frequency of use of the 7 Basic QC tools, and as to whether they are used often or not at all. The benefits and CSFs for the use of the 7 Basic QC tools are also explored. Finally, the research will ascertain how often QA professionals utilise the wrong or incorrect tool when problem-solving. In summary, the questions that the researchers seek to address are:

1. Is Ishikawa's statement that his 7 tools solve 95% of quality-related issues applicable in modern European organisations?
2. How often are the 7 tools utilised overall and at an individual tool usage level within European organisations?
3. Are there benefits and CSF's to applying Ishikawa's QC tools in European organisations?

2. Literature Review

7 Basic QC tools were developed by Kaoru Ishikawa and they are a suite of visual tools or techniques identified as being critical for use in problem-solving and aiding finding the root causes of quality issues (Kiran, 2017). Having little statistical based knowledge is not an impediment to utilisation of Ishikawas tools to correct quality issues -hence the categorisation of these tools is as "basic". Techniques are a collection of tools that facilitate positive change and improvements and help implement change when used together (McQuater et al., 1995; Ishikawa, 1985).

Ishikawa advocated primarily the use of simple tools for problem solving and to remove obstacles to improvement, co-operation, provide training, aid teamwork and using circles for quality improvement (Antony et al., 2021). Other authors such as Mach & Guáqueta (2001) and Tennant (2001) have researched Ishikawa's tools and other techniques.

Quality tools have many benefits for displaying data visually, helping identify and prioritise areas requiring attention; demonstrating relationships between variables; working out a problem cause, and showing the data patterns of distribution (Lamb & Dale, 1994; Bergman & Klefsjo, 1994) The main goals of using quality tools are encouraging working in teams, and to improve communication to aid the detection of issues (Marsh, 1996).

Ishikawa (1990) wrote that his 7 tools will solve 95% of problems within a workplace and advanced statistics would only be required for 5% of issue resolution. Ishikawa elaborated that most defectives arose from only a very small number of causes and removing these issues will reduce the quantity of defectives by 50% (Ishikawa, 1985).

The application and exploitation of the 7QC tools is not as widespread and effective as expected due to insufficient training in using and applying these approaches (Bamford & Greatbanks, 2005). He et al. (1996) discussed that many of Ishikawas tools are not usable for dealing with qualitative data as the majority of Ishikawas tools (6 of the 7) are used to analyse numerical data. Indeed in 1976, the Japanese Union of Scientists and Engineers (JUSE) put forward 7 new management QC tools alongside the 7 Basic QC tools (Mizuno 1988). New quality tools also known as the 7 new tools (or the seven management tools; M7) include affinity diagram, relation diagram, tree diagram, matrix diagram, matrix data analysis (prioritisation matrices), process decision program chart (PDPC) and procedure diagram.

Some CSFs for utilising quality tools include having the commitment of the top management team and their commitment to drive improvement, providing training, a requirement for the opportunity to utilise tools and a culture of collaboration and teamwork (McQuater et al., 1995). In addition, understanding the objectives of utilising an individual tool is important , and its prerequisites, benefits, and barriers to implementation is vital in its successful usage (Spring et al., 1998).

Many benefits are garnered by problem-solving to influence the financial bottom line

and profits. However, the wrong tool being utilised can result in the wrong root cause and the wrong corrective action being applied and having to go and restart the problem definition and associated process solving

process again (Hagemeyer et al., 2006). Tools being introduced for a defined purpose were better applied and utilised than those applied without a specific objective in mind when training was given.

González-Benito et al. (2003) discussed how vital it is in utilising a combination of tools rather than an individual tool to solve issues and provide solutions. When utilising QC tools, mistakes can occur, including using the wrong quality tool or not knowing the methods in which tools should be applied (Hagemeyer, Gershenson and Johnson, 2006). Lagrosen and Lagrosen (2005) have found in a study a correlation in tool usage for problem-solving and good quality management. Soundly based education delivered by informed and reliable trainers is very important to the early and correct success in using quality tools (Bunney & Dale, 1997). Indeed, the 7 Basic QC tools are very popular as integrated within a DMAIC problem-solving structure and within operational excellence improvement methodologies (Six Sigma, Lean, Lean Six Sigma) (Hollingshed, 2021).

The 7 QC tools put forward by Ishikawa are valuable tools for management of quality and implementing process improvements. However, he did not elaborate or discuss further on the utilisation and how his seven tools could be applied outside of the Manufacturing environments and other functions. The benefits and the CSF's in implementation and applying the tools are clear. Applying the 7 Basic QC tools and using the tools, however, can result in challenges.

The authors utilised a survey which was distributed online for data collection targeted at European professionals working in quality roles in all areas of responsibility across all functions. The benefits of surveys conducted online include expediting distribution and access, ease of use, inexpensive, flexible, and are more automated (Schaefer & Dillman, 1998; Lefever et al., 2007). Quantitative online survey methods are an appropriate method for this a study such as this. 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 as to what type and training levels that the respondents had in Ishikawa's seven tools and establish information about various aspects of the use of the tools. The authors contacted people working in quality functions

and roles from LinkedIn requesting their participation in the research through emails and through the private messaging system on LinkedIn before sending them the survey. Before distributing the survey, prior contact with potential respondents helped gain respondent commitment to questionnaire completion before distribution (Flynn et al., 1997). This questionnaire was written and structured to be short as, generally, professionals are under work pressures and do not have available time to complete long surveys. The survey was piloted with ten experts as piloting is recommended best practice before distribution to the wider group of participants (Puleo et al., 2002; Boynton & Greenhalgh, 2004). The objective of the piloting exercise was to ascertain which questions needed improvement from a practical standpoint and check that nothing had been omitted by the survey authors (Forza, 2002). The majority of the respondents from the pilot were that the survey was well written and hence the survey was ready to send out to respondents.

Survey participants details were drawn via LinkedIn, and participants were emailed. Similar methods had been utilised in other research (Hundal et al., 2021; Antony & Sony, 2019; Antony et al., 2021). The criteria for the identification and picking of respondents was that ; i) all participants should be working in a quality related role, (ii) should be employed in an organisation at some level within the Quality department (iii) Should be employed in either the manufacturing or within a service organisation. The total responses received was 228 which was collected over a time frame of 18 weeks. This gave a 60% response rate. Multiple samples were taken from some organisations, and this gave less biased answers and ensured consistent responses.

3. Results

The first question asked of respondent's was, "Have you been trained in Ishikawa's quality tools?". 84% of respondents stated they had been trained in Ishikawa's tools. This was not surprising because the authors specifically targeted quality professionals for the study and as the seven tools are integral within many traditional quality training programs. The next question was asked about the percentage of quality related problems in the respondent's organisations that could be solved by utilising Ishikawa's tools (Table 1).

Table 1. Quality related problems in the respondents organisations that could be solved by utilising Ishikawa 7 basic tools of quality by %

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 study's data analysis suggests that just 15% of all respondents were of the opinion that Ishikawa's tools could solve above 90% of business problems across European organisations. This contradicted Dr Ishikawa's claim (Ishikawa, 1982) that his 7 tools could solve over 95% of organisational problems. It is evident that in modern-day organisations that Ishikawa's tools are unable to solve all quality problems. The tools have usefulness, but a more comprehensive toolset is required. These results correlate with the viewpoints highlighted in the published research literature stating the 7 tools do not help deal with qualitative data (He et al., 1996). Mizuno (1988) highlighted that Ishikawa's tools do not foster planning for strategy and in-depth qualitative analysis. The

dawn of a new evolution of quality or Quality 4.0 with the increased digitalisation of organisations creates a chance for organisations to incorporate technology into their operational excellence and quality management programs. An opportunity exists to relook at how Ishikawa's tools can help with present day quality management problems. In an effort to gauge how much usage there was of Ishikawa's tools in Europe among quality personnel, the respondents next were questioned about their frequency of using them (Table 2). In Europe the most often utilised of Ishikawa's tools in order of voting were Pareto diagrams, histograms, and thirdly the cause and effect diagrams applied for analysis of quality related issues and problems. The usage of Ishikawa's tools in order of frequency of utilisation are listed below (Table 2). The least utilised tools was the scatter diagrams followed by stratification analysis.

Table 2. Usage of Ishikawas tools

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 next question asked was, "*In what functional areas within your organisations are Ishikawas tools utilised?"* (Table 3). The frequency of the application of Ishikawas tools as a set is more frequent in Manufacturing areas than in any other organisational functional area. Most tools for use within quality management originated within manufacturing environments, so this is not surprising. Ishikawas tools were utilised least frequently within HR, IT and Administration functions.

Table 3. Proportion of Ishikawas tools usage across different functions of European organisations

	Sales	Production	Supply Chain & Logistics	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 next question asked of the respondents was a question in relation to the benefits of Ishikawa's tools. The question is designed to establish what benefits the respondents had observed from the use of the 7 Basic QC tools within their own experience. The primary benefits of utilising Ishikawa's tools in European organisations were 1) provides a structure to problem-solving and aiding in the determination of the true cause of the organisational problem being analysed and 2) aiding personnel in the measuring and analysis of problems and 3) aiding problem solving (see Figure 1).

(Lagrosen & Lagrosen, 2005) amongst other authors, have highlighted similar benefits in utilising quality tools in influencing improved customer and process orientation, improved continuous improvement, solving of issues related to quality and management by facts.

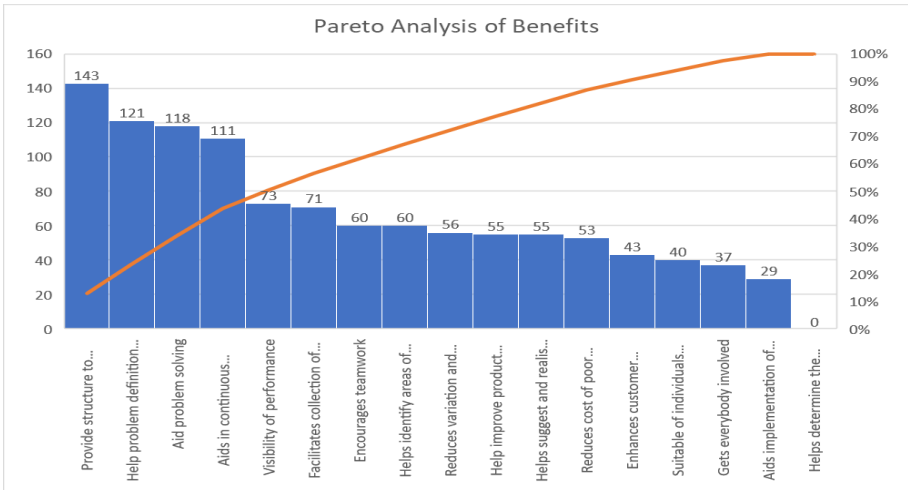


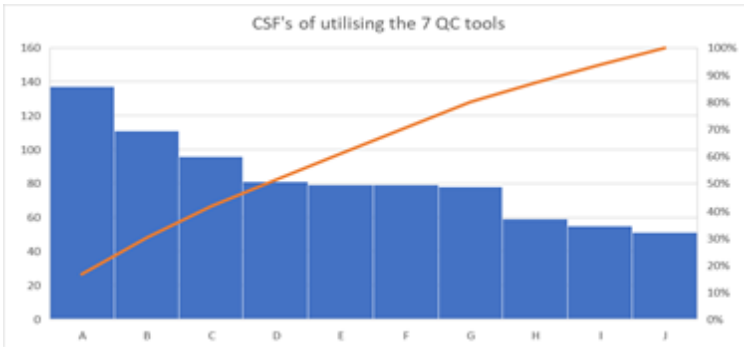
Figure 1. Benefits of utilising Ishikawas tools

Next another subsequent question was asked to ascertain how challenging the introduction and application of Ishikawas tools are. Identified challenges in the use of Ishikawas tools in Europe included lack of knowledge in relation to the tool usage, methods for collecting of data were weak, shortage of training, poor education and knowledge of the tools, and poor support from management. These findings were aligned with other published and previously cited research about incorrect utilisation of the 7 basic QC tools attributed to inadequate training processes (Hagemeyer et al., 2006). In addition, Bunney & Dale (2000) also highlighted the importance of implementing training and utilising the training session it as a method of defining the problem or requirement with management leading the way.

The QA professionals were also asked, “What CSFs are required to apply Ishikawas tools of QC?”. The main CSF’s as outlined in Figure 2 were: management support, having a CI program, providing an approach that is disciplined, having opportunities for tool utilisation and opportunities for participation in problem-solving sessions. The least ranked CSF's were gaining recognition and gaining reward at a team level, the communication of success stories and of resulting benefits and the creation of a sense of importance and urgent need by the management team. Also, these CSF's are a component of creating a problem-solving culture and teamwork, while important CSF's were not considered highly in the respondents answers.

Another question asked was, "How frequently have you used the wrong or incorrect tool when problem-solving?”. The respondents indicated that 40% had used the right tools, while 60% felt they had misused quality tools. This demonstrates how misunderstanding and misapplication of Ishikawas tools and inadequate training in using Ishikawas tools can be costly for an organisation. If an organisation takes the time to commit resources and effort to problem-solving, it is usually in response to a customer need and hence a potential loss of revenue. Ishikawa did not expand on which of the 7 basic QC tools were suited best in certain situations, only that using the tools alone or in

combination would resolve 95% of an organisation's problems. The fact that so many respondents felt they had used the incorrect tools correlates with the finding that many respondents did not believe that the 7QC tools solve more than a certain % of their organisation's problems.



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 Ishikawas tools Pareto & Legend.

4. Discussion

Ishikawa proposed his seven tools over 40 years ago. Although all of the respondents who partook in this research have received training in Ishikawas tools for problem-solving, many still find challenges in utilising and applying them. Ishikawa's tools can be at times inconsistently applied with some tools utilised more than others and, in some functions, more than others. Also, Ishikawas tools are still confined to traditional manufacturing companies and manufacturing-related functions despite organisational efforts to concentrate and prioritise efforts on the customer and quality across all departments and units within organisations. Given the correlation with utilising appropriate tools for aiding effective quality management and problem solving techniques in a TQM or in an organisational comprehensive quality initiative (Hellsten & Klefsjö, 2000) -this should be addressed when setting out on an organisational-wide training program.

Ishikawa's work more than 40 years ago put forward that over 95% of organisational problems could be resolved using his tools (Ishikawa, 1982). The author's findings from this research found that just 15% of respondents replied that >90% of issues related to quality and problems could be rectified utilising Ishikawas tools in European organisations. Indeed a mere 34% of respondents stated that Ishikawas tools could tackle between 1% and 50% of organisational problems.

The original or basic tools of Ishikawa are included in almost every type of quality educational or training program or curriculum, thus it is opportune to address how Ishikawas tools are being taught and what other type of tools should be utilised going forward. As Ishikawas tools were deemed unsuitable for strategic planning and dealing with qualitative data (Mizuno, 1998)

this correlates with our findings of Ishikawa's tool's lack of suitability for solving over 95% of organisational problems.

The tools most utilised among Ishikawas tools were Pareto diagrams, Histograms diagrams and Cause and Effect diagrams. The least applied of Ishikawas tools found in this study were the Scatter diagram and also Stratification analysis diagrams. Further data analysis found that Ishikawas tools were utilised more infrequently within the HR, IT and Administration functions. The advantages of applying Ishikawas tools are aiding and helping with problem solving, aiding in structuring to the solving problems and aiding defining of problems, as well as the analysis of the issue causing the problem. A relationship exists between successful tool usage and adequate training in the tools with good quality management practice and aiding of effective continuous improvement programs.

The identified challenges in using Ishikawas tools include non-understanding and knowledge in relation to the tools, inadequate methods for collection of relevant data, inadequate or little training given to employees to aid application and use of Ishikawas tools. The CSFs to the use of Ishikawas tools are ensuring that management support the use of the tools, the importance of having a current ongoing continuous improvement program, and a structured approach to tool usage, which correlates with (Rodgers et al., 2021). The research finding of most interest was that across European organisations 40% of professionals applying Ishikawas tools have utilised the incorrect tool when first approaching a problem. The reasons for misapplying tools relate to the CSFs of utilising the tools. Poor training and no training combined with not understanding tools can contribute to using the incorrect tools and going back and starting the process of problem-solving again. Also, as previously discussed, most of Ishikawas tools do not transfer for non-numerical data and qualitative data, and thus the deployment and utilisation of Ishikawa's tool suite may not solve the relevant organisational problem under study.

This research has many managerial implications. This research is being carried out decades after Ishikawa's work, and it questions its applicability nowadays in modern organisations if in fact 95% of organisational issues are not being resolved by utilisation of Ishikawas tools. In that case, quality management

educational programs and training need to cover what other tools should be designed into the quality management toolset to aid problem-solving in modern organisations. Secondly, Ishikawa never elaborated as to how his tools can be helpful in all organisational areas such as IT, HR, the supply chain, Marketing, Sales, and Finance. This lack of focus on areas other than manufacturing areas goes against the company-wide TQM culture of entire organisational involvement.

This study analyses whether Ishikawas tools are being utilised and applied and in what areas they have been applied most often in combination and where they have been utilised least often. This can direct leadership to ascertain areas where there are problems and training opportunities within an organisation to deploy these functional and easy to use tools as part operational excellence deployment programs and problem-solving exercises. It was found that 40% have utilised Ishikawas tools incorrectly and there are cost implications in this misuse, in terms of time wastage and misuse of resources in organisations. CSFs found in this study will be informative for senior management to consider while applying Ishikawas tools in any efforts at problem-solving . The limitations within the study are as follows: the majority of respondents were from Ireland and the UK, with a minority from France, Spain, and Germany. An opportunity to increase the survey spread with a higher % participation from across all of Europe exists. Future research opportunities

are with more exploratory qualitative research with semi-structured interviews with a wider population of quality personnel.

5. Conclusions

Based on the study's findings Ishikawa's statement that his tools can solve 95% of quality-related problems can be challenged in European organisations. Less than 15% of the European respondents indicated that just over 90% of the problems could be rectified utilising Ishikawas tools. This study demonstrated that Pareto diagrams, Histograms and Cause and Effect diagrams are the most deployed of Ishikawas tools in European organisations, and the Scatter diagrams and Stratification analysis are used most infrequently. Despite the findings mentioned above, there is still a strong case for using these tools for aiding problem-solving efforts and aiding continuous improvement when deployed correctly. According to European QA professionals, the key benefits of the utilisation of Ishikawas tools include aiding problem-solving, providing structure to any initiatives for solving of problems, and helping analysis of problems.

The key CSF's to correctly applying Ishikawas tools as found from this study were (1) having senior management communication and support, (2) having an ongoing operational excellence or continuous improvement program, (3) having a disciplined approach for problem-solving.

For further research, the authors would like to focus a wider study on a more global level and to further investigate why Ishikawas tools can be utilised incorrectly in efforts at solving problems. Also, with increased digitalisation and the evolution of Quality 4.0, investigating what tools and skills are relevant for the professional training curriculum of the future for quality personnel is important.

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References:

Antony, J., McDermott, O., Sony, M., Fernandes, M., & Ribeiro, R. (2021). 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. The TQM Journal, 33(8), 1770-1786. doi: 10.1108/tqm-01-2021-0004

Antony, J., & Sony, M. (2019). An empirical study into the limitations and emerging trends of Six Sigma in manufacturing and service organisations. *International Journal of Quality and Reliability Management, 37*(3), 470-493. doi: 10.1108/IJQRM-07-2019-0230.

Bamford, D. R., & Greatbanks, R. W. (2005). The use of quality management tools and techniques: A study of application in everyday situations. International Journal of Quality and Reliability Management, 22(4), pp. 376–392. doi: 10.1108/02656710510591219.

Bergman, B., & Klefsjo, B. (1994). *Quality, from Customer Needs to Customer Satisfaction*. London: McGraw-Hill.

Boynton, P. M., & Greenhalgh, T. (2004). Selecting, designing, and developing your questionnaire. *BMJ*, *328*(7451), 1312-1315.

Bunney, H. S., & Dale, B. G. (1997). The Implementation of Quality Management Tools and Techniques: A Study. *The TQM Magazine*, *9*(3), 183-89.

Evans, J. R., & Mathur, A. (2005). The value of online surveys. *Internet Research*, *15*(2), 195-219.doi: 10.1108/10662240510590360.

Flynn, B. B., Schroeder, R. G., Flynn, E. J., Sakakibara, S., & Bates, K. A. (1997). World-class manufacturing project: overview and selected results. *International Journal of Operations & Production Management, 17*(7), 671-85.

Forza, C. (2002). Survey research in operations management: A process-based perspective. *International Journal of Operations and Production Management,* 152-194. doi: 10.1108/01443570210414310.

González-Benito, J., Martínez-Lorente, A., & Dale, B. (2003). A study of the purchasing management system with respect to total quality management. *Industrial Marketing Management, 32*(6), 443-454.

Hagemeyer, C., Gershenson, J. K., & Johnson, D. M. (2006). Classification and application of problem solving quality tools: A manufacturing case study. *TQM Magazine, 18*(5), 455-483. doi: 10.1108/09544780610685458.

He, Z., Staples, G., Ross, M., & Court, I. (1996). Fourteen Japanese Quality Tools in Software Process Improvement. *The TQM Magazine, 8*(4), 40-44.

Hellsten, U., & Klefsjö, B. (2000). TQM as a management system consisting of values, techniques and tools. *The TQM Magazine, 12*(4), 238-244. https://doi.or,g/10.1108/09544780010325822

Hollingshed, M. (2021). Standardising Six Sigma Green Belt Training: Identification of the Most Frequently Used Measure Phase DMAIC Tools. I*nternational Journal of Lean Six Sigma ahead-of-print* (ahead-of-print). https://doi.org/10.1108/IJLSS-12-2020-0220 (October 26, 2021).

Hundal, G. S., Thiyagarajan, S., Alduraibi, M., Laux, C. M., Furterer, S. L., Cudney, E. A., & Antony, J. (2021). Lean Six Sigma as an organisational resilience mechanism in health care during the era of COVID-19. *International Journal of Lean Six Sigma.* doi: 10.1108/IJLSS-11-2020-0204.

Ishikawa, K. (1976). *Guide to quality control.* Asian Productivity Organization.

Ishikawa, K. (1985). *What is total quality control?* .Prentice-Hall.

Ishikawa, K. (1990). *Introduction to quality control*. Chapman & Hall.

Juran, J. M. (1988). *Juran on planning for quality*. New York: Free Press.

Kiran, D. R. (2017). In total quality management: key concepts and case studies. Elsevier.

Lamb, G. E., & Dale, B. G. (1994). Quality Improvement in Research and Development: A Study, *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 208*(4), 253-257. doi: 10.1243/PIME_PROC_1994_208_086_02

Lefever, S., Dal, M., & Matthíasdóttir, Á. (2007). Online data collection in academic research: Advantages and limitations. *British Journal of Educational Technology, 38*(4), 574-582. doi: 10.1111/j.1467-8535.2006.00638.x

Lagrosen, Y., & Lagrosen, S. (2005). The Effects of Quality Management – a Survey of Swedish Quality Professionals. *International Journal of Operations & Production Management, 25*(10), 940-952.

Mach, P., & Guáqueta, J. (2001). Utilisation of the seven Ishikawa tools (old tools) in the six sigma strategy, in Proceedings of the International Spring Seminar on Electronics Technology. *IEEE Computer Society*, 51-55. doi: 10.1109/ISSE.2001.931009.

Marsh, J. (1996). *The Quality Toolkit*. Leeds: Rushmere Wynn.

McQuater, R., Scurr, C., Dale, B., & Hillman, P. (1995). Using quality tools and techniques successfully. The TQM Magazine, 7(6), 37-42. doi: 10.1108/09544789510103761

Mizuno, S. (1988). *Management for Quality Improvement: The 7 New QC Tools*, 2nd ed. Portland: Productivity Press.

Puleo, E. , Zapka, J., White, M.J., Mouchawar, J., Somkin, C., & Taplin, S. (2002).Caffeine, cajoling, and other strategies to maximise clinician survey response rates. *Evaluation and the Health Professions, 25*(2), 169-184. doi: 10.1177/01678702025002003.

Rodgers, B., Anthony, J., & Cudney, E.A. (2021). A Critical Evaluation of Organizational Readiness for Continuous Improvement within a UK Public Utility Company. Public Money and Management.

Schaefer, D. R., & Dillman, D. A. (1998). Development of a standard email methodology: Results of an experiment. *Public Opinion Quarterly, 62*(3), 378-397. doi: 10.1086/297851.

Spring, M., McQuater, R., Swift, K., Dale, B., & Booker, J. (1998). The use of quality tools and techniques in product introduction: An assessment methodology. *TQM Magazine, 10*(1), 45-50. doi: 10.1108/09544789810197855.

Tennant, G. (2001). *Six Sigma: SPC and TQM in Manufacturing and Services*, 1st ed. London: Gower.

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