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Abstract

Purpose – The main purpose of this study is to revisit Ishikawa's statement "95% of problems in processes can be accomplished using the original 7 Quality Control (QC) tools". The paper critically investigates the validity of this statement in higher education institutions (HEIs). It involves analysis of the usage of the 7 QC tools and identifying the barriers, benefits, challenges, and critical success factors (CSF's) for the application of the 7 QC tools in a HEI setting.

Design/methodology/approach – An online survey instrument was developed, and as this is a global study, survey participants were contacted via social networks such as LinkedIn. Target respondents were HEIs educators or professionals who are knowledgeable about the 7 QC tools promulgated by Dr Ishikawa. The professionals work in administrative sectors, such as libraries, information technology, human resources were included in the study. A number of academics who teach the 7 basic tools of QC were also included in our study. The survey link was sent to over 200 educators and professionals and 76 complete responses were obtained.

Findings – The primary finding of this study shows that the diffusion of seven QC tools is not widespread in the context of HEIs. Less than 8% of the respondents believe that more than 90% of process problems can be solved by applying the 7 QC tools. These numbers show that that modern-quality problems may need more than the 7 basic QC basic tools and there may be a need to revisit the role and contribution of these tools to solve problems in the higher education sector. Tools such as Pareto chart and Cause and Effect diagram have been widely used in the context of HEIs. The most important barriers highlighted are related to the lack of knowledge about the benefits and about how and when to apply these tools. Among the challenges, are the "lack of knowledge of the tools and their applications" and "lack of training in the use of the tools". The main benefits mentioned by the respondents were "the identification of areas for improvement, problem definition, measurement, and analysis". According to our study, one of the most important factors critical for the success of the initiative were "management support", "widespread training" and "having a continuous improvement program in place".

Research limitations/implications – The exploratory study provides an initial understanding about the 7 QC tools application in HEIs, their benefits, challenges, and critical success factors, which can act as guidelines for implementation in HEIs. Surveys alone cannot provide deeper insights into the status of the application of seven QC tools in HEIs and therefore qualitative studies in the form of semi-structured interviews should be carried out in the future.

Originality/value – This article contributes with an exploratory empirical study on the extent of the use of 7 QC tools in the university processes. The authors claim that this is the first empirical study looking into the use of the seven QC tools in the university sector.

Keywords – Ishikawa, 7 Quality Control Tools, Higher Education Institutes (HEIs), Survey, Quality Improvement.

Paper type – Research paper

1. Introduction

Quality Management has evolved as a discipline over time and has been aligned with industrial progress. After the first industrial revolution, the quality inspection was introduced to identify defects in production lines. Quality inspection evolved into a more focused approach to quality control (QC) with the advent of WWII (Zairi, M. 2013; Antony et al., 2022). The QC was introduced to formalize the quality process by ensuring product quality is maintained or improved (Bendell et al., 1995). The next stage of this quality evolution was the advent of the Quality Assurance (QA) mechanism, which focused on preventing defects rather than simply detecting them and adhering to standards that set minimum quality levels. Later, the emergence of TQM (Total Quality Management) has been touted as a significant development in quality management practice (Prajogo and Sohal, 2001; Tsang and Antony, 2001). During the evolution of these quality management principles, five Quality Gurus' contribution is substantial. Kaoru Ishikawa is one of the quality gurus who contributed immensely to the improvement of the quality. Ishikawa was student of Deming, Juran, and Feiganbaum. He is known for the cause & effect diagram, also referred to as Isikawa's diagram (Carvalho et al., 2021). He is also known for introducing quality circles, continuous training, a quality chain, and seven QC tools. He was closely associated with the Company-Wide QC movement in Japan between 1955 to 1960. He simplified the application of statistical tools through the well-known seven QC tools for shop-floor operators (Krüger, 2001; Zairi, M., 2013).

The seven QC tools can be considered the flagship contribution of Ishikawa, including check sheets, scatter diagrams, histograms, Pareto analysis, cause and effect diagrams, stratification, and control charts (Antony et al., 2021a). Even though these tools are developed to enhance the quality of the production processes in a manufacturing environment, these are used effectively in healthcare settings (Carvalho et al., 2021), hospitality (Ramadan et al., 2022) and other service industries (He et al., 1996; Bamford et al., 2005). Today, Higher Education

Institutions (HEIs) is considered to be one of the prominent service industries contributing to the economic growth of any country. Also, HEIs play a unique and transformative role in fulfilling countries' critical labour needs and competitiveness and improving efficiency and effectiveness (Valero and Reenen, 2019). Moreover, the digital transformation of education via online and hybrid forms creates an immense opportunity to leverage seven QC tools to improve the process and service delivered to customers(Raju et al., 2021; Bhat and Jnanesh, 2013).

According to Ishikawa, "the seven QC tools, if used skilfully, will enable 95% of workplace problems to be solved. In other words, intermediate and advanced statistical tools are needed in only 5% of cases" (Ishikawa, 1990). Nevertheless, Ishikawa did not precisely mention the basis for quantifying these values in the statement and did not provide an elaborated explanation to justify the same (Antony et al., 2021a). Moreover, researchers have paid little attention to validating Ishikawa's value and view in a structured approach. According to the research carried out by Antony et al. (2021b), less than 25% of the quality professions in the manufacturing and service sector claimed that seven QC tools could solve above 95% of the business problems. Also, 40% of quality professionals indicated that they wrongly applied the seven QC tools "right first time" during problem-solving. This indicates that it is high time to comprehend the applicability and contribution of 7 QC tools in the era of Quality 4.0 (Q4.0).

Even though most of the quality management research is reported by academicians, there is limited evidence of its usage in academia (Sunder, 2016; Zighan and EL-Qasem, 2021). Interestingly, many HEIs have sponsored "Quality Management" projects to unearth the relevance and applicability of quality management principles in academia. Most of the "quality" initiatives within the HEIs have focused on non-academic activities (such as finance, admission, placement, accreditation, and accommodation management) and used quality management tools in a non-random basis and not in a systematic manner (Koch, 2003). Also, it is reported that HEIs prefer simple tools such as basic seven QC over their counterparts (Jasti

et al., 2021a). However, no literature reports the usage of seven quality tools in the HEIs context. Thus, it is essential to comprehend the same in a structured manner by considering typical barriers, fundamental challenges, critical success factors, and benefits of applying the seven basic tools of QC in this context. This would validate Ishikawa's statement and pave the way for a holistic understanding of its relevance in the era of Q4.0.

It is observed that there is a lack of explanation about Ishikawa's seven basic QC tools in business processes outside the manufacturing sector and, in particular, their use in service industries and public sector organisations such as HEIs. The discussion on how the 95% can be distributed among the seven individual tools is also missing in the literature. Ishikawa was unaware of the transparency about the benefits and the CSFs for implementing the tools (Antony et al., 2021 a&b). This pilot study aims to explore how HEIs have used the seven QC tools in their processes and the internal variables that are considered such as barriers, challenges, success factors, and benefits from its applications in the HE context. Therefore, this research aims to develop a detailed understanding of the role of seven QC tools in HEI. Consequently, the research intended to investigate the following research questions (RQs).

RQ1: What is the relevance of Ishikawa's original statement that the "Seven QC tools can solve 95% of quality-related problems" in the HE context?

RQ2: What are the benefits of applying seven QC tools in the higher education settings?

RQ3: What are the barriers and challenges in using the seven QC tools in the higher education environment?

RQ4: What are the critical success factors (CSFs) for the effective use of seven QC tools in the higher education sector?

The article is structured as follows. Section 2 provides the literature review in line with the research objectives, and Section 3 explains the research methodology adopted for the study.

Key findings of the study are enumerated in Section 4, and findings are discussed in Section 5. The conclusion and directions for future research are provided in Section 6.

2. Literature Review

This section reviews relevant studies on Higher Education Institutions (HEIs) and the need for continuous improvement in HEIs. The recognized academic databases have investigated, academic journals and articles that are based on strong and deep analysis of findings. The "source" for research literature was Scopus database and google scholar. Search strings were used as follows: HEIs "OR" Higher Education Institutes "AND" Quality Control tools "OR" QC OR tools "OR" Ishikawa. A detailed discussion is done on the seven Quality Control tools and their relevance in continuous improvement, followed by the Benefits, Barriers, Challenges, and Critical Success Factors (CSFs) in the application of the Seven Quality Control Tools.

2.1 Higher Education Industry

In recent years, there is an increasing awareness that a nation's economic affluence and competitiveness is critical to the quality of higher education imparted to its citizens are closely linked together (Sayeda et al., 2010).

The primary objective of a country is to achieve sustained growth, economic development, health and well-being of people. The prime focus to achieve this growth depends on the readiness factors of technology hub accessibility and natural resources to be used and renewed. Human resources play a vital role in assessing all these resources and progress towards the nation's development. Thus, the training of these human resources is very significant. Higher Education is responsible for imparting education and training to the youth, improving the competent workforce accessibility exponentially, which is critical for a country's economic growth (Jasti et al., 2021a). The twentieth and twenty-first centuries have observed higher education's part in the country's sustainable economic growth.

The education industry is one of the critical service industries which strives to achieve continuous improvement to survive and compete in the vibrant market (Tight,2020, Dwaikat, 2020). Education Industry is primarily responsible for preparing workforce that caters to all the sectors of the economy.

Educational institutions help evolve innovation, research, and entrepreneurship. They help confront societal and national challenges while preparing youth for their life and career. Thus, higher education's role is crucial for the upliftment of society and the country by shaping the future of young scholars (Litten, 1980; Bynner et al., 2003).

Prakash (2018), developed a systematic literature review, presented classifications, procedures, projects, and operationalization of quality concepts in HEIs. Societal Goals require to be expanded to improve the ability of HEI to produce quality.

2.2 Need for Continuous Improvement in Higher Education Institutions (HEIs)

Quality excellence focuses on the customer satisfaction of the manufacturing and service industry through a continuous improvement process. The previous decades exhibited that Quality has become an important parameter for the researchers and the practitioners due to its potential to improve the performance of an organization, customer satisfaction level and loyalty, and profitability simultaneously lowering the costs (Leonard and Sasser, 1982; Nitin Seth et al. 2005). Quality is a highly subjective topic, and its perceived notion varies according to the industry. In HEIs, quality is often measured as per the university standards and global rankings (Pozzi et al., 2019). Due to the competitive market forces, achieving and maintaining quality goals is mandatory in HEIs.

Higher Education offers prospects to the people to exhibit crucial issues challenged by humanity in cultural, social, and economic disciplines. Higher Education delivers expert knowledge and a proficient workforce for national development (Symaco, 2013). The application of TQM in higher education started in 1985 in the USA. Owing to the enhanced

competition and constrained support on the financial resources, only two colleges have attempted to implement the TQM in higher education (Owlia and Aspinwall, 1997). In the next seven years, more than 220 institutions have implemented TQM (Elmuti et al., 1996), and more than 415 institutions were involved by the year 1994 (Michael et al.,1997), which was remarkable. In the late 1990s and the 2000s, the TQM in higher education was globally recognized. One of the aspects of continuous improvement is the application of basic and advanced tools for tackling process and quality related problems in organizations. The focus of this research is on the use of basic 7 tools of QC in the context of HEIs.

2.3 Seven Quality Control Tools and their relevance to continuous improvement

The basic seven tools of Quality control (QC), or the seven traditional tools, promulgated by Dr. Kaoru Ishikawa, are a collection of graphical methods recognized as being most helpful in solving a number of quality-related issues (Kiran, 2017). The tools can be considered "basic" because an individual with no knowledge or training in statistics can easily use these tools to solve quality or process related issues in the organization.

Quality Control (QC) comprises creating, planning, making, and promoting servicing products and services with optimum efficiency and value for the customers. Ishikawa, 1993 stated that the different departments of an organization must “work together” to achieve these aims. Deming and Ishikawa acknowledged that an organization’s significant problems exist within their processes or systems (Suárez-Barraza and Rodríguez-González, 2019).

Ishikawa was confident in using the simple procedures to work simultaneously on resolving the issues in an organization and eliminating difficulties in development, training, and education on how to use quality tools for problem solving, cooperation, and coordination among teams (Tummala and Tang, 1996).

Like Ishikawa (1976) and Juran (1988), the quality gurus have written about quality management tools and their implementation. Asher and Dale (1989), Barker (1989), Dale et al.

(1997), Bunney and Dale (1999), and Bamford and Greatbanks (2005) have also contributed their work in the use of quality management tools and their application in an organization.

Many authors and academicians have discussed the benefits of quality tools. The quality tools help in making a complex data into a simple visualization, identifying the areas with the most difficulties, prioritizing troubleshooting areas, displaying the relationship among the variables, creating the root cause, and displaying the distribution of data (Mach and Guaqueta, 2001 and Tennant, 2001). The implementation of the quality tools primarily helps communication between the management and the operators, identifying and prioritizing the problems (Dale and Shaw, 1991; Marsh, 1993; Dale et al., 1997). Quality tools can be efficiently applied to any business process, and they are not limited to only manufacturing processes (Ahmed and Hassan, 2003).

Ishikawa (1990) acknowledged 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 restated in his “What is Quality Control?" book in 1995 that "95% of problems in processes can be accomplished by using the 7 QC tools" and that innovative techniques and computers are a prerequisite in very complex processes. Ishikawa did not explain or validate these statements further.

Implementing the quality management tools and techniques faced difficulties in the availability of the resources to introduce the tools and ensuing use (Bunney and Dale, 1997). Another challenge is applicability of the tools in service context as the explanation on the tools is primarily from manufacturing context (He et al. 1996).

2.4 Benefits, Barriers and Challenges, and Critical Success Factors (CSFs) of Seven Quality Control Tools

Antony et al, (2012; 2020) present a comprehensive treatment on barriers, challenges, and CSFs in implementing Lean Six Sigma for HEIs. In particular, the barriers and challenges

include translating LSS terminologies from manufacturing to higher education setting, unclear strategy, lack of awareness, short sightedness and focus on quick improvements, lack of leadership, communication, and resources. Important tools that enable efficient and effective improvement are process mapping, cause-and-effect analysis, visual management, Pareto analysis, SIPOC, project charter, rapid improvement workshop. The CSFs for implementation of LSS were top management support and commitment, communication at all levels, leadership, organization culture, availability of adequate resources and skills, choice of project and its prioritization (Antony et al., 2012; 2020).

CSFs significantly impact how successfully and efficiently any tool can be used (McQuater et al.,1995). These CSFs comprises a need to use the tool or technique, a supportive environment for the implementation of the tool, trained staff and the facilitators, and last, but not least, support and guidance from the management (Antony et al., 2021a; Antony, 2020).

Past research was predominantly on cost benefits of problem-solving and the assessing the cost of quality. However, the researchers do not discuss the consequences of using the wrong QC tool. Using the wrong tool results in the wastage of the resources, time loss, and cost engaged in the possible defects of an organization. Bunney and Dale (1997) explained that one tool/ technique is not a complete solution to solve an organization's problems. To support this, González-Benito et al.(2003) laid the significance of using a blend of tools to highlight the relationships and the differences.

The research gaps identified from literature indicates the lack of explanation about Ishikawa's seven basic quality tools in business processes outside manufacturing sector and in particular their use in service industries such as HEI. The discussion on how the 95% can be distributed among the seven individual tool's is also missing in the literature. Ishikawa was not aware of the transparency about the benefits and the CSF's for implementing the tools. In this pilot study we aim to explore how Higher Education Institutions (HEIs) have used the seven QC tools in

their processes and the internal variables that are considered barriers, challenges, success factors, and benefits of the application of such tools.

3. Research Methodology

This is an exploratory study, since it aims to gain preliminary insights on a given topic (Forza, 2002). The pilot study allows for greater knowledge on the subject and preliminary analysis of the research instrument. The survey research design needs a structured process composed of a number of steps, including development of the research questions and objectives, link to the theoretical domain, design of the survey questionnaire, define target population and sampling frame, pretesting of the questionnaire, analyse data and report the findings of the study (Flynn et al., 1990; Forza, 2002; Hair et al., 2020). The objective of this pilot study is to explore how Higher Education Institutions (HEIs) have used the seven-quality control (QC) tools in their processes and the internal variables that are considered include: barriers, challenges, success factors and benefits of the application of the seven basic tools of *QC*.

3.1. Pilot study design

The first step in the development of the survey was to connect with the theoretical domain (Forza, 2002), and to answer the research questions, a well-executed questionnaire design process is needed to obtain reliable and valid data (Hair et al., 2020). The questionnaire format will determine the type of questions and, consequently, the kind of data analysis (Antony et. al., 2007; Hair et al., 2020). The main information about the design of the questionnaire is presented in Table 1.

Table 1- Questionnaire design processes

Questionnaire Design Steps	**Procedures**
Select the variables/indicators to represent the concepts and measurement scale	The variables were identified in the literature review based on studies about seven QC tools and QC in HEIs.

Define target population and sampling frame	The aim is to carry out a pilot test for a global study on the use of Seven basic tools of QC promulgated by Dr Ishikawa. The target population is HEI professors and administrative workers with some understanding of the QC tools from different regions of the world.
Determining question types, format, and sequence	The questionnaire was designed with closed questions and divided into two sections. The first one was related to HEIs and the respondents' profile. The second part was focused on the use of the seven QC tools in general and in different HEI processes, most and least used tools, and so on. The section also included questions about barriers, challenges, and benefits of using the Likert scale (1-strongly disagree; 7-strongly agree).
Pretesting the questionnaire	The pre-testing was carried out with 6 academic specialists, 3 specialists who work in practice with the theme and 2 target respondents, to cover both theoretical and practical aspects of seven quality control tools. The objective was for respondents to indicate difficulty in completing, responding or lack of questions and in the sequence of questions.
Pilot surveying the questionnaire	As this is a longitudinal study, the authors will initially execute a pilot survey and develop another survey based on the findings of the first survey.
Report	The analysis of the questionnaire allowed preliminary analysis on the use of seven QC tools in HEIs.

The research instrument used for data collection was an online questionnaire, which facilitates collecting data in a shorter time frame and minimizes the associated costs (Couper and Miller, 2008; Antony and Sony, 2021). The questionnaire was developed using Google Forms and had two sections. The first section included the characterization of HEI (location, public or private type and size) and respondent details (position, years of experience and knowledge of the seven QC tools). The second section was dedicated to obtaining information about the use of the seven QC tools, critical success factors, barriers, challenges and benefits from the application of these tools. Questions related to barriers, challenges and benefits attempted to measure perceptions. The statements were evaluated using the 7-point Likert scale (1-Strongly disagree; 7-Strongly agree) as recommended by several authors (e.g., Sullivan and Artino, 2013; Hair et al.,2020).

Target respondents are lecturers or professionals working in the administrative sectors of the HEIs, such as libraries, IT, finance, and human resources, among others. As this is a global study, the authors utilized their network contacts on LinkedIn to approach target respondents with the desired profile and experience (i.e., HEI professionals who are knowledgeable about the seven QC tools). This procedure was followed by similar studies on the subject (e.g., Antony et al., 2019; 2021a). The survey link was sent to 200 professionals, a sample of 77 respondents was obtained, however, 8 respondents indicated not having knowledge about the tools, leaving a final sample of 69 respondents (34.5% response rate), which is quite satisfactory for pilot surveys (Forza, 2002;Antony, 2004; Antony et al., 2008).

3.2 Data analysis

The data were analysed using descriptive (graphs and frequency analysis) and non-parametric statistics. The non-parametric Friedman test is conducted to rank a list in order of importance and ascertain whether the rank values represent a statistical difference (Sheskin, 2006). Values for Friedman test lower than 0.05 (p-value<0.05) indicates a statistical difference in the relative importance among the factors. As in similar research in the area of quality (e.g., Amran et al., 2021; Godinho Filho et al., 2016), In this study Friedman's test was used to rank the barriers, challenges, and benefits of using QC tools, as performed by other studies in the area of quality (e.g., Amran et al., 2021; Godinho Filho et al., 2016; Eswaramoorthi et al., 2011).

4. Key findings

4.1 Sample characterization

The sample is mainly composed of faculty members (65%) and Directors/Deans/H.O.Ds (14%). Most of the respondents (nearly 80%) work in academic processes (Teaching and Research) followed by Administrative processes (about 16% of the sample) (Table 1). Majority of the respondents were male respondents (68%) and although they all are aware of the seven QC tools (a necessary criterion to participate in the survey), only 55% of the respondents had

received any formal training in the seven basic tools of QC. Although the seven basic QC tools are among the most useful and popular tools used in many types of organizations today (Antony et al., 2021b), HEI professionals are still not widely trained. Table 2 also shows that most of the respondents were familiar with the basic tools of QC (more than 80%) although they were not formally trained.

Table 2: Respondent characteristics

Respondent Position	**Number**	**%**	**Process that the respondent works**	**Number**	**%**
Faculty member	45	65%	Academic (Teaching & Research)	49	71%
Director/Dean/H.O.D	10	14%	Administrative	10	14%
Administrative Member	1	1%	Professional Service Processes	3	4%
Staff member (Management Committee)	1	1%	IT	2	3%
Librarian	1	1%	HR Processes	1	1%
Vice Principal	3	4%	Marketing and Recruitment Processes	1	1%
IT department	2	3%	Finance Process	1	1%
Other	6	9%	Quality and Risk Management	1	1%
			Not answered	1	1%
Total	**69**	**100%**	**Total**	**69**	**100%**
Gender	**Number**	**%**	**Training in the QC tools**	**Number**	**%**
Female	21	30%	Yes	38	55%
Male	47	68%	No	31	45%
Not answered	1	1%			
Total		**100%**	**Total**	**69**	**100%**
Experience in the HEI	**Number**	**%**	**Understanding of QC tools**	**Number**	**%**
< 1 year	2	3%	Not at all familiar	1	1%
Between 1 year and <5 years	15	22%	Slightly familiar	12	17%
=5 years and <10 years	23	33%	Familiar	21	30%
=10 years and <15 years	12	17%	Very familiar	16	23%
=15 years and <20 years	8	12%	Extremely Familiar	19	28%
=20 years or 20 + years	8	12%			
Not answered	1	1%			
Total	**69**	**100%**	**Total**	**69**	**100%**

Table 3 presents the HEIs location and size. The sample of HEIs is distributed over several continents and as can be seen in Table 2, the institutions are located primarily in Asia (52%) and Europe (26%), but there are HEIs from five continents, allowing a global view of the application of the seven QC tools. The sample comprises diversity of HEI sizes, with 56%

having more than 500 employees and 43% of the sample less than 500 employees (refer Table 3).

Table 3: Companies characteristics

HEIs location	**Number**	**Percentage**
Asia	36	52%
Europe	18	26%
South America	6	9%
North America	4	6%
Australia	3	4%
Not answered	2	3%
Total	**69**	**100%**
HEIs size	**Number**	**Percentage**
< 500	30	43%
Between 501 and 1000	7	10%
Between 1001 and 1500	3	4%
>1501	28	41%
Not answered	1	1%
Total	**69**	**100%**

4.2 Relevance of Seven QC tools in HEIs' processes

The respondents were asked about the percentage of quality problems that can be tackled using the seven basic QC tools in the Higher Education sector, and the results are presented in Figure 1. Almost equal percentage of the sample (48% and 49%, respectively) indicates that they apply or do not apply the quality tools. This shows that the diffusion of the use of these tools is not yet completely spread in the context of HEIs.

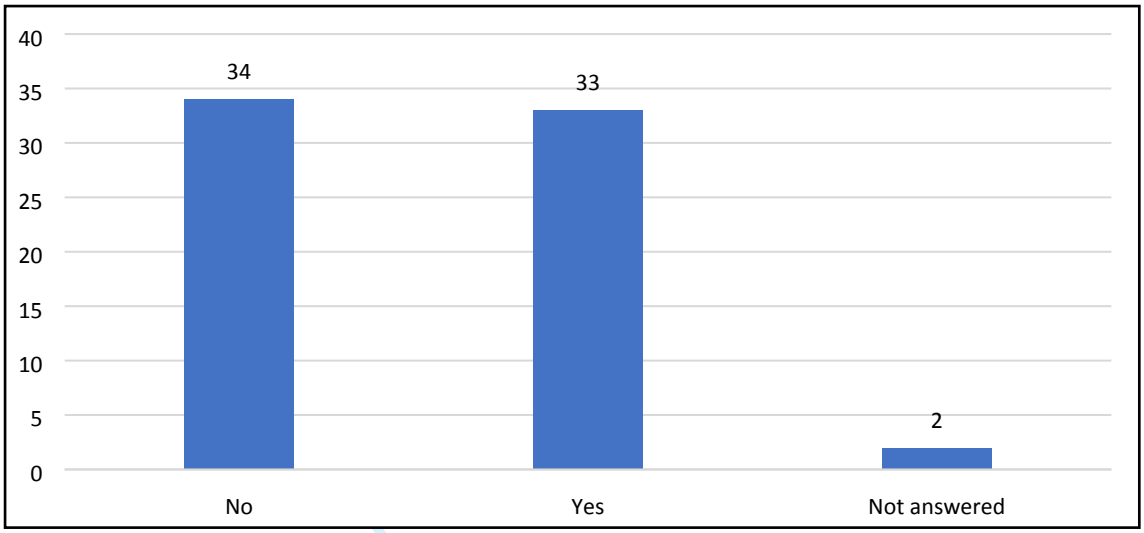

Figure 1: Application of the seven QC tools in the HEIs' processes

Figure 2 shows that 68% of respondents indicated that less than 10% of HEI employees are trained on the seven QC tools. This shows that the diffusion of tools in this sector is still incipient. This fact is different from the manufacturing or service sector, where more than 80% of employees are trained in these tools (Antony et al., 2021b).

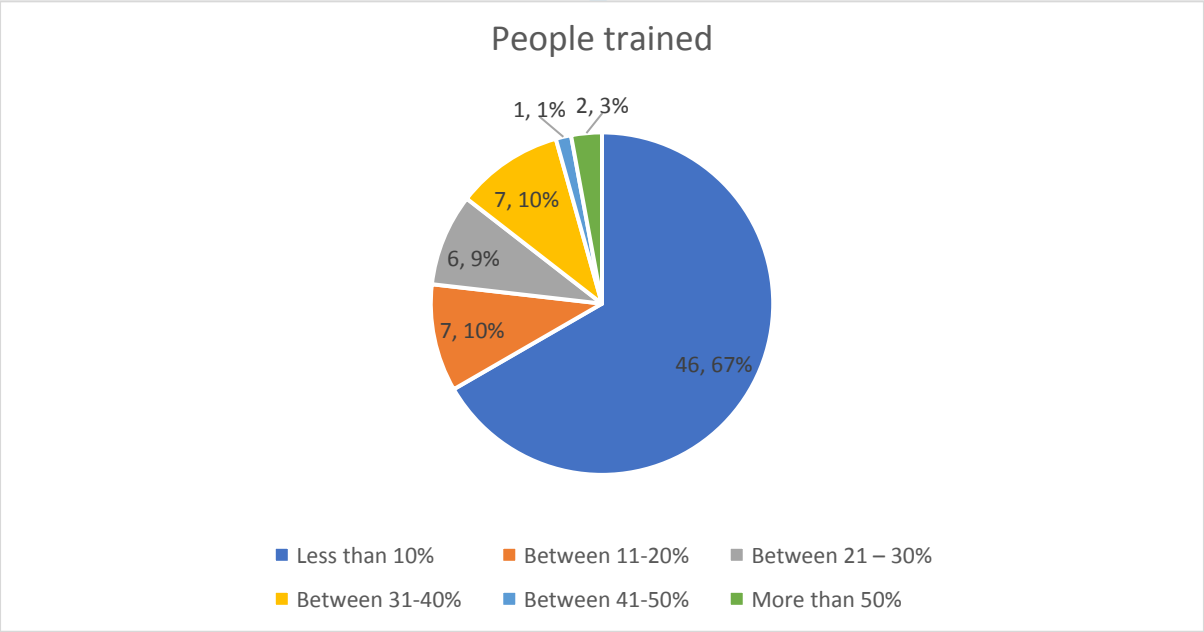

Figure 2: % of an organisations problem that can be solved by the 7 QC tools HEI's employees trained in the seven QC tools

Dr. Kaoru Ishikawa (1985) stated in his book "What is Quality Control?" that 95% of problems in processes can be accomplished by the use of the seven QC tools. To verify this frequency of

use in the context of HEIs, respondents were asked about the tool's usage in each of the main processes or functional areas. Figure 2 shows that less than 8% of the respondents believe that more than 90% of the process problems in Professional Services can be solved by applying the seven QC tools. An even smaller number of respondents validate this statement for the other HEI processes. Approximately 50% of respondents believed that the tools address up to 50% of the problems. Therefore, these numbers show that modern-quality problems may need more than the seven basic QC tools and there may be a need to revisit the role and contribution of these tools to solve modern quality problems in many organizations today (Antony et al., 2021b). Studies have shown that although these tools of QC are not solving many problems in organisations, they have been used effectively in most continuous improvement journeys (e.g.: Lean / Lean Six Sigma) of Higher Education Institutions with some challenges (Svensson et al., 2015; Antony et al., 2012; Antony et al., 2018).

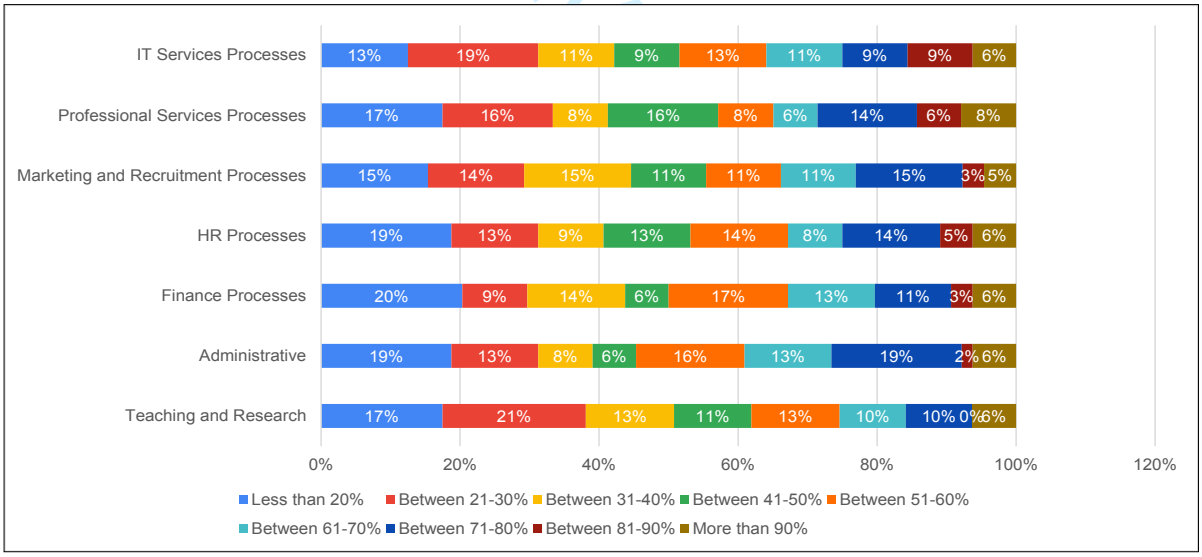

Figure 3: What percentage of quality problems in different HEI functions can be addressed using the seven basic tools of QC promoted by Dr Ishikawa

4.3 Seven QC tools usage in HEI processes

To understand what seven QC tools the HEIs employees are using in HE processes, the respondents were asked the most used (refer Figure 3) and the least commonly used (refer Figure 4) tools among the seven basic tools. Respondents were asked to check multiple boxes against the list of seven basic tools of QC as the purpose of this task was to capture the type of tools used for problem solving scenarios in the HE sectors. It was found the most frequently used seven quality tools were the following: *Histograms, Check Sheets, Cause and Effect diagram, and Pareto analysis.* A study by Antony et al. (2012) has shown that both Pareto chart and Cause and Effect analysis have been widely used in the Higher Education Institutions and this justifies the findings of the present study.

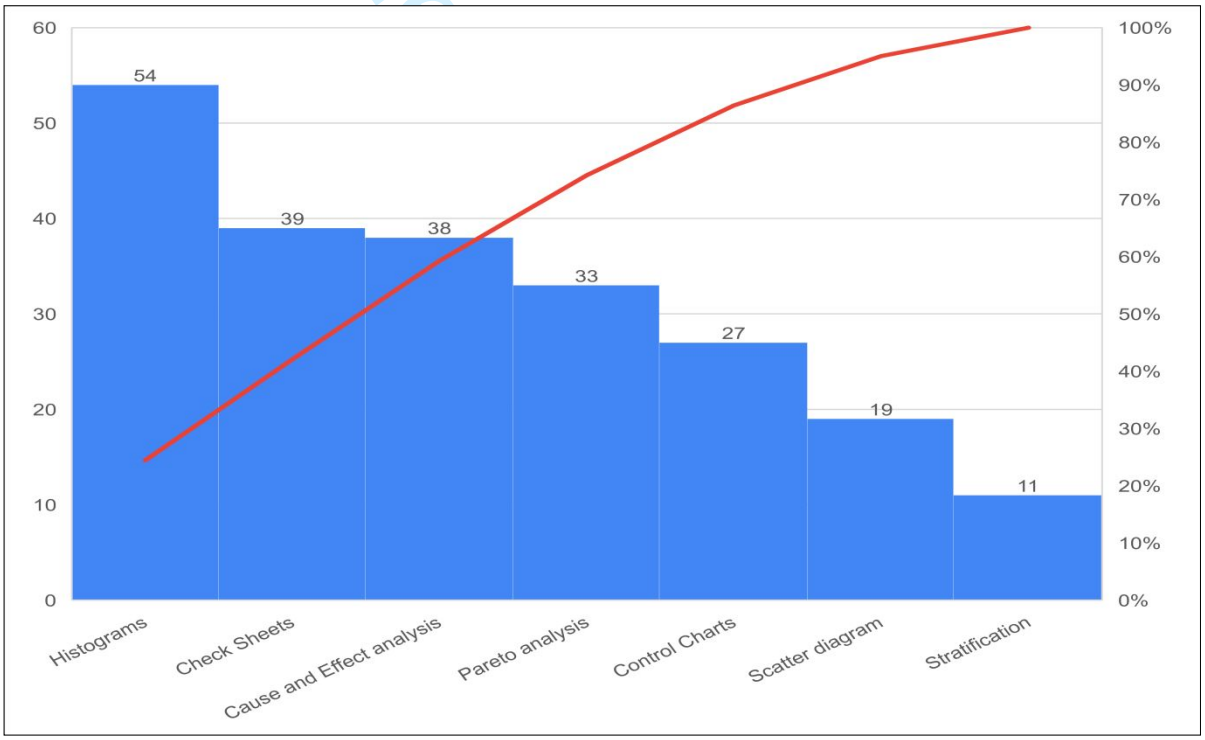

Figure 4: The most used among the seven basic QC tools

The low use of certain tools is confirmed when respondents are asked about the least commonly used tools (refer Figure 5). The least used tools are Stratification, Control Charts, and Scatter Diagram. The low frequency of use associated with Stratification has been reported in a recent global study (Antony et al., 2021a). The difficulty in use may be due to tools such as Control Charts and Scatter Diagrams that require a knowledge of statistics, lack of understanding where

to use in problem solving exercises, and, in this sense, more training, limiting the application in a context in which few people know or apply the seven QC tools (Toledo et al., 2021). In addition, the culture of data collection is not so prevalent in many HEIs, and this restrains the application of control charts and scatter diagrams. Finally, it was also reported recently that these tools are less frequently used in service and public sector companies (Antony et al., 2021b).

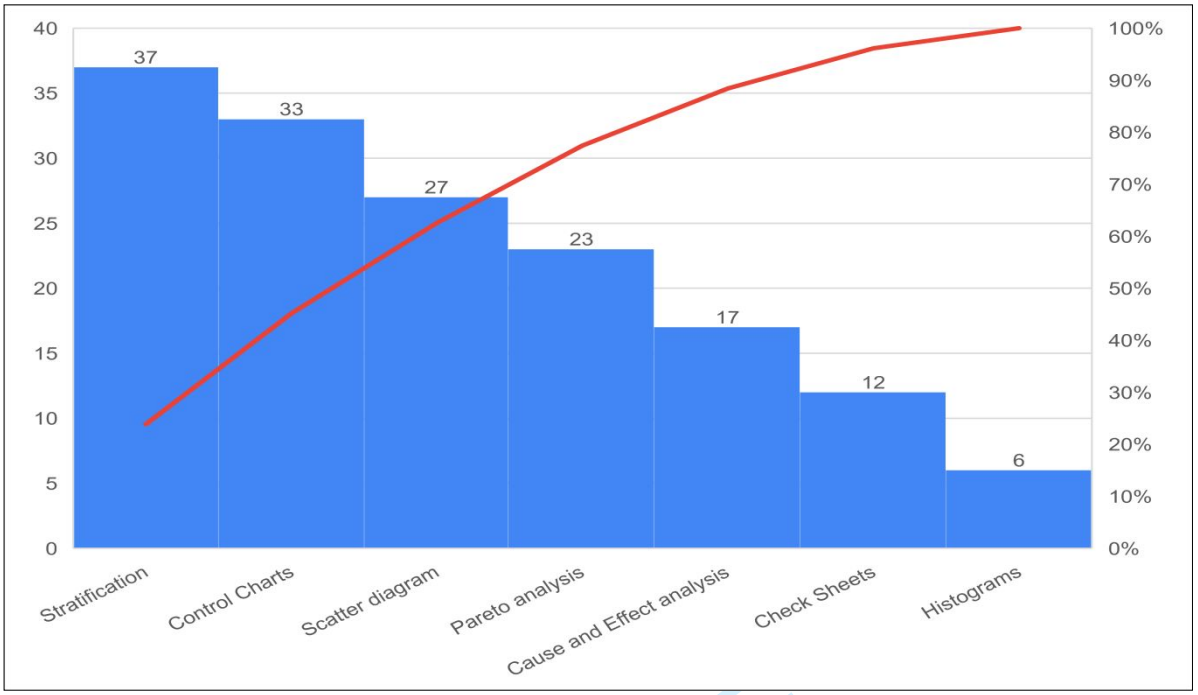

Figure 5: The seven basic QC tools in order of least usage

Figure 6 shows the extent of the use of seven basic tools of QC across various processes in the Higher Education sector. Respondents of the survey pointed out that Check Sheets as the most used tool in all processes, with the exception of within Teaching and Research functions. The same four tools pointed out as the most used are also designated as the most used across most HEI processes: *Histograms, Check Sheet, Pareto and Cause and Effect analysis.* The respondents indicated the greater use of Scatter Diagrams in the marketing and recruitment processes and in the professional services processes. This is because, these two functions need to understand the relationships between various customers from different backgrounds and

ethnicity and their performances for instance. Moreover, one can utilize the use of Scatter plot to understand the relationship between students' background and their dropout rates in a typical undergraduate program.

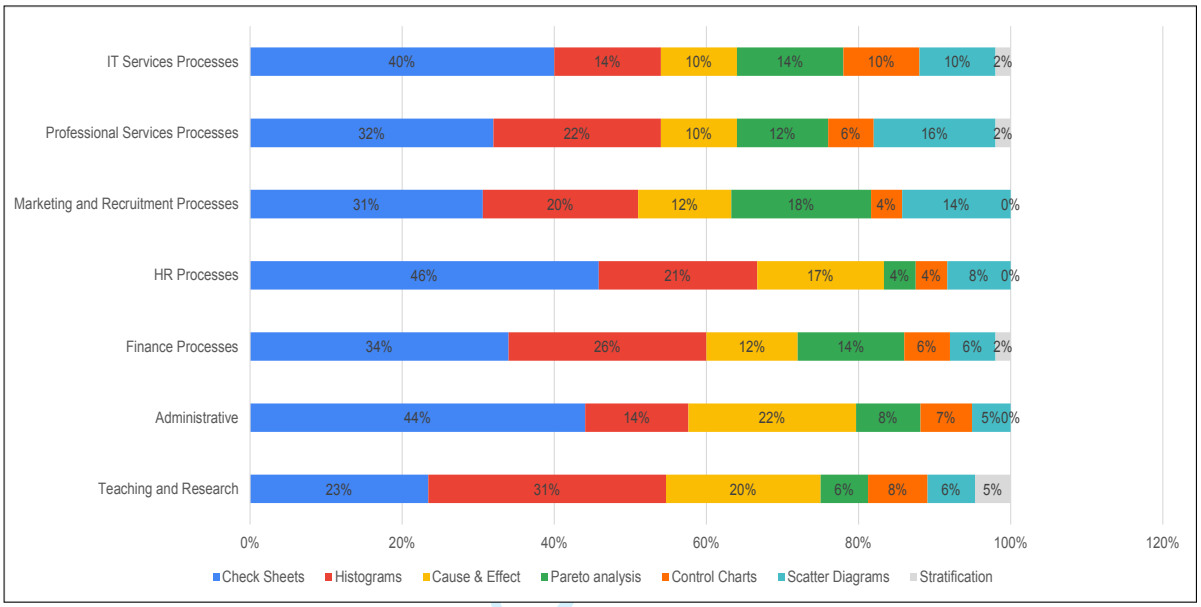

Figure 6: Application of QC tools in HEI processes

4.4 Barriers, Challenges and Benefits

Respondents were asked about the barriers to applying the seven QC tools in the HEIs (refer Table 4). The most important barriers identified in our study were "*Lack of awareness regarding the benefits of tools*", followed by "*Lack of understanding of when and where to apply the tools*" and finally "*Lack of training to develop the skills needed to use the tools*". The results suggest that that there is a greater lack of understanding in the benefits that can be derived from the use of seven basic QC tools. Moreover, the senior management has not provided a suitable environment for the application of such tools which includes budget for training, time to carry out projects related to process improvement using the basic tools of QC, etc. Studies in the HE sector indicate the need for and importance of promoting hands-on applications in the use of quality control tools which lead to process excellence across the HEIs (Cudney et al., 2020).

Table 4: Ranking of barriers to the adoption of seven basic QC tools

Barriers	Mean	Median	Std. Deviation	Min	Max	Mean Rank
Lack of awareness regarding the benefits of tools	4.44	5.0	1.32	1	6	7.11
Lack of understanding of the tools as to when and where they should be used	4.44	5.0	1.36	1	6	6.80
Lack of training to develop the desired skills in the use of the tools	4.33	5.0	1.34	1	6	6.70
Lack of education in universities on the seven tools of quality control	4.25	4.0	1.45	1	6	6.53
Lack of top management commitment, involvement and support	4.10	4.0	1.68	1	6	6.30
Lack of motivation in the use of tools	4.18	4.0	1.32	1	6	6.05
Lack of employee involvement and empowerment	4.07	5.0	1.45	1	6	6.05
Barriers related to organisational culture	3.89	4.0	1.57	1	6	5.56
Lack of time due to other priorities in the organisation	3.89	4.0	1.58	1	6	5.47
Lack of communication	3.85	4.0	1.34	1	6	5.40
Lack of financial resources	3.34	3.5	1.57	1	6	4.03

N=61; Friedman test (Qui-Square =54.565; p-value<0.001)

In addition to the barriers, the respondents were asked to identify the challenges that exist in the use of the seven basic QC tools in HEIs (refer Table 5). The main challenges identified were "*Lack of knowledge of the tools and their applications to improve the processes of the HEIs*", *"Lack of management support"* and "*Lack of training in the use of the tools*". These same challenges appear as the most cited in manufacturing and service companies for the use of seven QC tools (Antony et al., 2021a). The findings suggest that lack of training could

potentially lead to lack of understanding on the benefits of the basic tools of QC and both are due to the lack of commitment from senior management in the HE sectors.

Some of the other challenges such as lack of teamwork, poor data collection methods, poor communication, and poor attitude towards quality improvement projects, make us think that HEIs definitely need to have proper training and wholehearted support from top management. The support from top management facilitates in developing the attitude towards problem solving. Proper communication about the requirements from top management also help in developing better communication between team members resulting better teamwork. Thus, our research shows the need for top management commitment to not only overcome training and education on tools but also developing better teamwork and better mindset in problem solving.

Table 5: Ranking of challenges to the adoption of tools

Challenges	Mean	Median	Std. Deviation	Min	Max	Mean Rank
Lack of knowledge about the tools and their applications in improving university processes	5.32	6.0	1.62	1	7	8.35
Lack of management support	5.27	6.0	1.83	1	7	8.03
Lack of training on the use of tools	5.25	5.0	1.66	1	7	8.01
Lack of a quality mindset and culture in the university sector	5.12	5.0	1.90	1	7	7.64
No sense of urgency for the use of quality tools	5.03	5.0	1.90	1	7	7.59
Lack of understanding on the benefits of tools	5.00	5.0	1.56	1	7	7.47
Lack of education	4.83	5.0	1.75	1	7	6.96
Not using the right tools at the right time	4.80	5.0	1.63	1	7	6.48
Poor data collections methods	4.72	5.0	1.64	1	7	6.47
Poor attitude towards quality improvement projects	4.60	5.0	1.95	1	7	6.39

Lack of teamwork	4.52	4.5	1.91	1	7	6.08
Poor communication	4.43	5.0	1.90	1	7	5.89
The tools can be seen only for the "administrative" department	4.33	5.0	1.77	1	7	5.64

N=60; Friedman (Chi-Square=56.735; p-value<0.001)

The respondents were also asked about the fundamental benefits of using the seven basic QC tools in a Higher Education setting, according to their perceptions. The three main benefits mentioned were: "*Helps in identifying areas for improvement", "Helps problem definition, measurement, and analysis" and "Facilitates collection, organization and presentation of data"*. The first benefit pointed out shows the importance of identifying areas or processes that need improvement and that the tools generate this contribution in the view of the respondents. The second and third main benefits mentioned are in line with the tools indicated as the most used tools. For example, Pareto analysis and Histograms can help in problem identification, definition, measurement, and analysis and Check Sheets support the collection, organization and presentation of data.

The three benefits least associated with using the tools are *"Helps to have a better visibility of performance", "Encourages teamwork" and "Enhances positive customer feedback through improving service quality"* (refer Table 6). This implies that HEI's do not use Control Charts in monitoring, analyzing, evaluating and improving the performance of critical processes. This is primarily due to the fact that the mindset and attitude of employees in the HE sector is very different from many manufacturing and service sectors. Due to the command-and-control culture exhibited within many HE institutions , employees do not feel comfortable in making their process performance transparent (Seddon, 2005). The requirements of HEI's customers varies differently and understanding the different types of customers is challenging (Antony et al. al., 2012). This resulted in the little impact of using the tools with increasing positive customer feedback to improve service quality by the respondents.

Table 6: Ranking of benefits of the tools' usage

Benefits	Mean	Median	Std. Deviation	Min	Max	Mean Rank
Helps in identifying areas for improvement	5.51	6	1.55	1	7	9.61
Helps problem definition, measurement, and analysis	5.61	6	1.45	1	7	9.59
Facilitates collection, organisation, and presentation of data	5.56	6	1.43	2	7	9.53
Provides a structure to problem-solving	5.58	6	1.49	2	7	9.38
Helps to determine the "true" root cause of the problem	5.46	6	1.64	1	7	9.23
Aids in continuous improvement	5.51	6	1.54	1	7	9.10
Helps problem solving	5.42	6	1.56	1	7	8.84
Suitable to solve basic problems related to process and quality issues	5.40	6	1.49	2	7	8.69
Helps to understand and reduce variation and improves the quality	5.23	6	1.69	2	7	8.38
Helps improving service quality	5.32	6	1.54	1	7	8.29
Aids implementation of other process improvement methodologies such as Lean, Six Sigma, etc.	5.23	5	1.67	1	7	8.18
Reduces cost of poor Quality (e.g.: rework, mistakes, errors etc.)	5.18	5	1.60	2	7	7.82
Gets everybody involved in problem solving efforts	5.12	5	1.64	1	7	7.67
Helps to have a better visibility of performance	5.07	5	1.61	1	7	7.47
Encourages teamwork	5.04	5	1.60	1	7	7.28
Enhances positive customer feedback through improving service quality	4.98	5	1.52	1	7	6.94

N=57; Friedman (Cui-Square=43.782; p-value<0.001)

4.5 Critical Success Factors

Respondents were asked about the Critical Success Factors (CSF) in implementing and using the seven basic Quality Control tools in HEIs. CSFs represent the essential ingredients without which any quality or continuous improvement initiative stands little chance of success (Antony et al., 2012). Figure 7 presents the most important critical factors for the successful application of tools: "*Management support*", "*Widespread training*" and "*Having a continuous improvement program*".

Figure 7: Success factors in implementing and using the seven basic QC tools

Without senior management commitment and support, any continuous improvement initiative can be a waste of energy, money, and time (Antony et al., 2012). Without training, employees will not be equipped with an understanding of the tools and their applications in problem solving scenarios. The support of an improvement program such as Lean, TQM, Lean Six Sigma, has already been pointed out as relevant for the HEIs sector (e.g., Jasti et al., 2021a; Cudney et al., 2020; Antony et al., 2012) and can provide the necessary roadmap for the use of

the tools, in conjunction with structured and systematic methodologies such as PDCA and DMAIC.

5. Discussion

The 7 Basic QC tools as put forward by Ishikawa for QC are around for over forty years. These tools are very valuable in aiding problem solving and helping in continuous improvement programs. There is a high awareness of the 7 QC tools in HEI's with over 80% stating that they were aware of the tools. However, despite there being a high awareness of the 7 QC tools only 55% of HEI participants stated that they were trained in the use of the tools. 68% of respondents indicated that less than 10% of HEI employees in the participant higher education institutions are trained in the seven QC tools. Previous studies on the usage of the 7 QC tools within the manufacturing sector have found that more than 80% of personnel are trained in the use of the tools (Antony et al, 2021a, Antony et al, 2021b). This finding is not surprising as continuous improvement programs and methods are much more matured within manufacturing and service companies compared to many public sector organisations such as HEIs. This difference suggests that HEI's have neither trained a large percentage of employees in the 7 basic tools, nor do they feel the need to train the employees as compared to manufacturing and service organizations. HEI's are more service related, consisting of many different administrative processes and traditionally continuous improvement methods are not prominent in HEI's. Another aspect observed in tools usage in service companies are related to statistical aspects. If the tools require more quantitative understanding, service organizations generally tend to shy away from their usage. One of the reasons behind is limited data generation in service companies and lack of transparency associated with processes (Chakraborty and Tan, 2013). Ishikawa stated that more that 95% of organisations problems can be solved by using the 7 QC tools. Within this study it was found that less than 8% of respondents believe that more than 90% of their Professional Services process problems can be solved by applying the seven QC

tools. An even smaller number of respondents agreed with this statement for the other HEI processes. This finding is not surprising given that only 58% of participants stated that they were trained in the 7QC tools and that 68% stated that less than 10% of their HEI's employees were trained in the tools. It is difficult for the 7 QC tools to potentially solve more than 95% of problems if people are not trained in their use or potential.

It was found the most frequently used seven quality tools were the following: Histograms, Check Sheets, Cause and Effect, and Pareto analysis. Check sheets and histograms are some of the simplest methods for collecting and determining trends and providing information for decision making (McQuater et al., 1995). This finding corresponds with many studies related to Quality Management tool and 7 QC tool usage where these aforementioned tools were the most utilised above all other tool types (Antony et al., (2021a, Antony et.al, 2021b, McDermott et al, 2021, McDermott et. al, 2022). The least used tools are Stratification, Control Charts and Scatter Diagrams which also corresponded with the previously cited studies on the 7 QC tools in the Manufacturing sector. These tools are more analytical and could be considered slightly more difficult to use than the most frequently utilised tools. Also, they may not have the same level of day-to-day application as histograms and check sheets for example.

The most important barriers to 7 QC tool usage identified in the study were "Lack of awareness regarding the benefits of tools", followed by "Lack of understanding of when and where to apply the tools" and finally "Lack of training to develop the skills needed to use the tools". It should be noted that the aforementioned barriers may lead to the wrong or incorrect tool being used. There are costs to using a tool incorrectly or for the wrong reason (Spring et al. 1998) and using the incorrect tool can slow down the problem-solving process. McQuater et al. (1995) identified use of tools and techniques at the wrong time and stage as an issue in tool utilisation and application.

These barriers found in the study aligned with the challenges identified which were "Lack of knowledge of the tools and their applications to improve the processes of the HEIs", "Lack of management support" and "Lack of training in the use of the tools". Many authors including Dale and McQuater (1998), Bamford and Greatbanks (2005) and Tarí and Sabater (2004) have discussed the importance of training, knowledge and understanding in the use and application of the tools. Lack of management support and creating of opportunities to use the tools has also been highlighted by many studies as an obstacle to tool usage and application (Bamford and Greatbanks, 2005; Bunney and Dale, 1997; Antony et.al 2021a, Antony et al.,2021b). The research about quality tools usage in service companies also suggests that it is difficult for service companies to generate projects on a continuous basis in long-term. Further, lack of data and available expertise to provide training also becomes hindrance in applicability of QC tools and techniques (Vashishth et al., 2017).

The three main benefits in the use of basic QC tools derived from the research include "Helps in identifying areas for improvement", "Helps problem definition, measurement, and analysis" and "Facilitates collection, organization and presentation of data". According to McQuater et al. (1995), tools and techniques are practical methods, skills, means, or mechanisms applied to particular tasks, and they are used to facilitate positive change and improvements. These benefits suggest that personnel in HEI's understand and see the value for the tools in improving the customer and student experience as well as structuring problem solving exercises.

The most important critical factors for the successful application of tools identified in the study were: "Management support", "Widespread training" and "Having a continuous improvement program". The main CSFs for the proper use of quality tools have been studied by Bunney and Dale (1997) and McQuater et al. (1995) amongst others. These CSFs in this study align with these authors findings of having full management support and commitment; effective, timely and planned training; a genuine need to use the tool or technique and having a CI program.

In addition to the alignment with the literature, other success factors which scored low needs also special attention. For example, low score for communicating the need for the application of tools by the senior management shows that the communication channels in HEI is not very open. Senior management does not feel the need for this communication which is very important for employees to understand the importance of QC tools and their usage. Similarly, the score of CSFs, sharing of success stories and benefits is low which shows that there is a need to have better story telling within HEIs to improve the employee morale and motivate them to learn from each other's successes. There is also a need to develop a knowledge base within the organization for better sharing of the project learnings and usage of tools.

6. Conclusion, Managerial Implications, Limitations and Future research

This article contributes to many managerial implications. Firstly, Ishikawa stated that more than 95% of organisations problems can be solved by implementing the 7QC tools but this research stated that 8% of the respondents believe in it. The authors are probing the original statement and wondering for what the other tools would be to solve the problems of HEIs apart from the basic 7 QC tools. Secondly, the CSFs classified in this research can be used as a vital guide for the professionals for the successful application of the tools in any HE settings. Moreover, the challenges/barriers reported and benefits in the use of the basic 7 QC tools can be very beneficial to all practitioners of continuous improvement in the HEIs.

Finally, this research has some limitations that must be documented. Firstly, the low response-rate of the survey limit the generalization of the findings of the research. Secondly, as it is a global study, another research should be done to validate the result as per the education system and different cultures of a country. Finally, the authors are designing an in-depth exploratory study in the form of semi-structured interviews or focus group with the quality professionals to gain more insights.

The future research with more quality professionals will validate the results of this study. So, it is relevant to consider expanding this survey and this would potentially increase the generalizability of the results. In addition, the future analysis will try to understand the critical difference in the application of QC tools within HEIs across various continents. Also, a number of qualitative studies will be pursued to understand the reasons for non-adoption of the seven QC tools in the HE setting and what opportunities are missed because of not widely accepting these tools in problem solving scenarios and building a culture of continuous improvement.

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