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The Implementation Effectiveness of Quality Tools and Techniques

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ABSTRACT

The need of QTT in continuous improvement can be seen in several studies and the research interest to quality tools and techniques is at the increasing trend. It is also contributing to the evolution of QTT with huge number of QTT were designed to fit the complexity of the problem to be solved. Thus, there is a need to have the indicator of implementation effectiveness for the practitioner to gauge the effort of implementing the QTT in actual environment. The purpose of this paper is to investigate the implementation effectiveness of quality tools and techniques among the practitioners in Malaysian industries based on the level of importance and the level of implementation. In the literature review, this paper only focuses on the articles by using the Scopus search engine to download the papers. Thus, relevant papers may have been excluded that may obtain from other search engine. In addition, the results obtained may only relevant in Malaysian industries. This research used a survey questionnaire to obtain the data and used descriptive analysis to tabulate the data in the form of frequency and percentage. The average mean score of the implementation level will be divided by the average mean score of the importance level to generate the index of implementation effectiveness. 169 QTTs were listed as an indicator to measure the implementation effectiveness. The result shows that the implementation effectiveness in the ranges of 60 percent to 94 percent and none of the QTT found over-focus or over than 100% of implementation effectiveness.

Key words: Implementation effectiveness, Quality Tools and Techniques (QTT)

1. INTRODUCTION

Quality cannot be obtained consistently by coincidence, but through the designated Quality tools and technique (QTT) are essential in the quality improvement methodology and is stated as one of the critical success factors in quality management and improvement implementation. [1] noted that utilization of QTT is considered to be essential as one of Six Sigma's critical success factors. Furthermore, many researchers have placed QTT as a success factor of TQM implementation and defined as elements of continuous quality improvement [2] [3], [4].

The importance of QTT in the above discussion encourages all industries to apply in their organization. The QTT is applied to a wide range of industrial processes such as manufacturing and non-industrial process such as healthcare. [5] found that the diversity of QTTs has been applied to TQM programs in various industries. It is also used in other improvement methodologies such as in ISO 9000, Six Sigma, and national quality awards [6], [7]. Additionally, [8] and [9] showed that QTT is able to apply in a wide range of the non-industrial process. The QTT also not only applicable to huge industries because [10] found that the QTT such as check sheet, process flow diagram, histogram, cause-and-effect diagram, Pareto analysis, p-chart, x-bar chart, r-chart, scatter diagram and c-chart could be applied in many small industries and all medium ones.

Table 1: Keyword used in Scopus search engine.

Keyword	Number of documents in Scopus
'Total Quality Management' and 'TQM' 'Tool Technique'	1,708
'Lean Six Sigma' and 'Lean' and 'Six Sigma' 'Tool Technique'	1,652
Total	3,360

The need of QTT in continuous improvement can be seen in several studies and the research interest to quality tools and techniques is at the increasing trend. [11] study the quality

movement under the subject total quality management and business excellence, found the increasing trend of the article's publication related to techniques and tools from 1987 until 2011. They also found that the amount of research in 2002–2011 is significantly higher than that in the first decade 1987–1996. The findings somehow tally with the result from the Scopus search engine. By using a few keywords as shown in Table 1, downloaded on January 2018, there are a huge number of documents found in the Scopus search engine. When arranging the sum of documents from each keyword in yearly basis, there is increasing trend from 1971 until 2017 as shown in Figure 1.

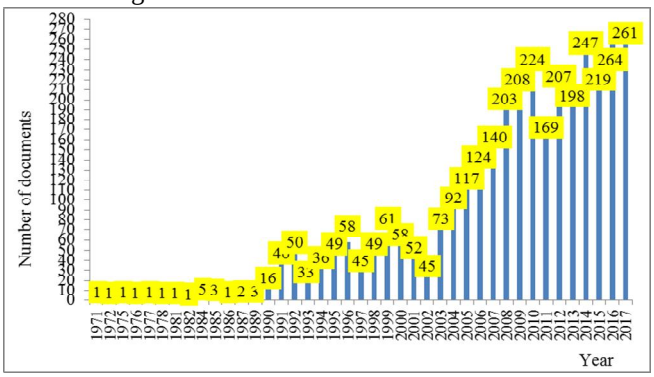

Figure 1: Keyword used in Scopus search engine.

Despite the trend above, it is important to review the current implementation level in actual practice as well as the implementation effectiveness. This paper attempted to provide evidence on the implementation effectiveness among the practitioner in Malaysian industries based on the level of importance and level of implementation that obtained through the survey questionnaire.

2. QTT IN PREVIOUS STUDY

The literature review in this study focuses on the list of QTT from previous study. The intention is not to compile the list of QTT but to use as the indicator of measurement of implementation effectiveness.

There are many QTTs available in quality improvement methodologies [12], [13]. QTTs from most of the methodologies contain very or almost similar concept [14]. [15] found that most of the QTTs are shared by all the methodologies and concluded that Japanese Total Quality Control (JTQC), Total Quality Management (TQM), Business Process Reengineering (BPR), Lean Thinking and Six Sigma are having nine common factors and one of them is QTTs. Another thought claimed that methodologies such as Six Sigma, Lean and TQM have many similarities, especially on the effects of quality objective and the usage of QTT, but differs in some areas, particularly on the main theory and approach [16]. Therefore, any selected well-known and promoted quality improvement methodology is sufficed in this study.

Hence, to ensure this study could cover as much as possible of the information related to the QTT, two types of methodologies will be set as a search scope and will be used in the search string. The first methodology will be referring to QTT that related to improvement and problem solving and this methodology is referred as Lean Six Sigma (LSS). The second methodology will be referring to QTT that related to management, namely Total Quality Management (TQM).

Without denied that LSS and TQM are not the only methodologies that effectively solve all quality problems and issues, but choosing these two methodologies in this study are sufficient to explore the practices and literature of QTT in both areas which are improvement and problem solving; and management concept and philosophy.

This study used Scopus search engine to find the documents related to the QTT in LSS and TQM that use for problem-solving and improvement activities. Several search string were used to find the documents namely 'Total Quality Management', 'TQM', 'Lean Six Sigma', 'Lean', 'Six Sigma' and 'Tool Technique'. Total 2,608 lists of documents were found that consist of 1,376 lists of documents related to QTT in TQM and 1,232 documents related to QTT in LSS. However, 1,038 lists of documents were removed due to duplicate documents, incomplete information and due to unrelated to QTT because there are few documents referred the tool as hardware such as apparatus, machine, and gadget and used term technique that referred to the procedure of the experiment and step of software development.

The remaining 1,570 lists of documents were further read to extract the list of QTT. Prior to the extraction of QTT list, the trend of publication related to QTT was then reconfirmed by constructing a bar graph. Fig. 2 shows the trend of publications related QTT based on LSS and TQM after the screening process is remained important.

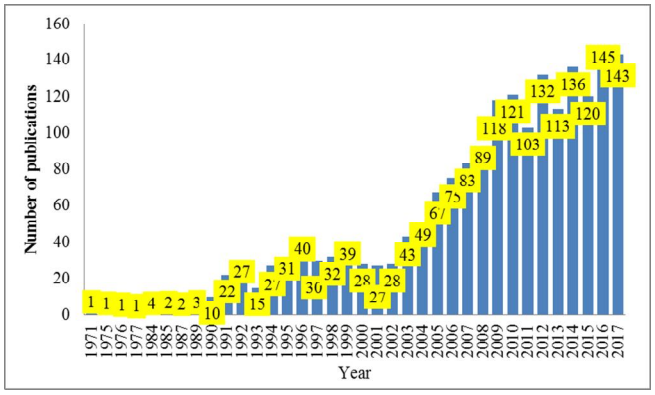

Figure 2: Trend of publications related QTT in LSS and TQM after screening.

Finally, total 47 documents were used to list out the QTT, that was obtained from the extraction process. However, from 47 documents, there were 6 references from another source besides Scopus with the intention to get more wide-ranging of QTTs list. These additional references were 5 from books and 1 from ISO Standard. On the other hand, these additional references receive quite a number of citations from previous researchers. As a result, sum of 1,552 QTTs found from 47 documents.

It is expected that the QTTs found from all above literatures will contain duplication, thus require a screening process to get the actual number of QTTs without duplication. The screening process is done by consolidating the QTT based on its terminology. Terminology is referred as the QTT that having a similar name and similar meaning. After a screening process, the sum of 670 QTTs were found with different terminology, thus this shows that there are a huge number of QTTs available for problem-solving and improvement activities. Furthermore this study found 495 QTTs were stated once in the in the 47 documents and 169 QTTs were found stated at least twice in the 47 documents.

Since this study narrows the scope of the improvement methodology to LSS and TQM, from the table above, there are 25 references listed the QTTs that related to TQM and 22 references of QTTs related to LSS. This background of references after being mapped to every 670 QTTs, there are 382 QTTs that only found in LSS literature, 183 QTTs found in the literature that related to TQM, and 105 QTTs can be found in both LSS and TQM. Thus, total QTTs that related to LSS are 487 and total QTTs for TQM are 288.The LSS QTTs is higher than TQM due to a result of the integration of Six Sigma and Lean. This QTT list is inclusive the most fundamental QTTs and the most commonly known which so call Basic 7QC Tools and New 7QC Tools. Both are listed in TQM and LSS methodology.

3. METHODOLOGY

3.1 Survey Method

The survey method was used to collect the data and information from the practitioners. The survey method was used in this study to obtain the factual information and opinion from respondents who directly involved in problem-solving and improvement activities. The survey is described as a method of questioning the respondents to obtain the data as responses to the context of the study and recorded data will be used for analysis [17]. A survey has many advantages such as the ability to reach at a broadly scattered sample with geographical flexibility, free from interview bias and it gives respondents ample to answers, prudent technique and economical method [18]. [19] highlighted that the survey method is relatively time-saving, cost-effective and energy saving.

The most common tool to collect the data from the survey is using questionnaire. Survey questionnaire enables this study to assess all respondents by the same instrument and under the same conditions [20]. The survey questionnaire method also allows the researcher to collect a large quantity of data in a shorter time with affordable cost and from several geographically dispersed areas. Therefore, the survey questionnaire is an appropriate means for this study.
Prior to conduct the full survey, the questionnaire was validated by expert and was sent to few respondents for the pilot study. Based on the feedback from the expert and result from the pilot study, the researcher had improved the questionnaire and conducted the final survey. The data that obtained from the questionnaire had gone through the screening process prior to conducting the analysis. The descriptive analysis was used to analyze the list of QTT that practiced by the industries in Malaysia.

Target populations of this study and the target subject as a unit of analysis were referred to the organization that practiced the improvement and problem-solving activities and related personnel who were involved directly and have experience in improvement and problem-solving in Malaysia.

In the questionnaire, the respondents were asked to rate the level of importance and implementation on each QTT based on the seven-point Likert scale. The scale range for the level of importance is from [10] ‘Not very important’ to [15] ‘Very important’ and the scale range for the level of implementation is from [10] ‘No implementation’ to [15] ‘Full implementation’.

Only 169 QTTs were listed as measurement items in this questionnaire, because of these QTTs were stated with at least from two documents or references. The QTT that only found in one document or reference in the literature is referred as QTT with low frequency. The low frequency of QTT is presume either as newly establish that cause the respondents may never hear this QTT before or this QTT was no longer being applied by the majority of the practitioner.

3.2 Implementation Effectiveness Index

The measurement of implementation level and importance level as a separate indicator does not reflect the effectiveness. The effectiveness can be seen through the execution of the implementation of QTT that will be prioritized based on the level of importance.

In this study, the implementation effectiveness refers to the QTT implementation level versus QTT importance level in

term of percentage. The average mean score of the implementation level will be divided by the average mean score of the importance level to generate the index of QTT implementation effectiveness as shown in below equation. From the result of below equation, if there is low implementation effectiveness, it is shown that the QTT importance level that viewed by the employees has not been successfully translated into practice in the companies. If there is more than 100 percent of implementation effectiveness, the indicators shows that the QTT is over-focus.

$$\text{Implementation Effectiveness} = \frac{\text{Average means score of Implementation level}}{\text{Average means score of Importance level}} \times 100\% \quad (1)$$

4. RESULT

The data obtained from survey questionnaire were analyzed using the IBM Statistical Product and Service Solutions (SPSS) version 23. The SPSS software was used to obtain the descriptive statistic. In this study, the descriptive statistic is used to tabulate and analyze the data from a survey in the form of frequency and percentage in order to describe the characteristic of the sample with respect to the demographic variables. Subsequently, the findings from the descriptive statistical analysis are used to measure the importance and implementation level of QTT in order to measure the QTT implementation effectiveness.

4.1 Response Rate

The number of responses received was 129 out of 309 questionnaires distributed. Of the 309 survey questionnaire, 11 surveys were found to have more than 10 percent of unanswered items. Thus, the useable questionnaires were 118 and the response rate was 38.2%.

4.2 The Importance and Implementation Level

This section analyses the importance level and the implementation level of QTT for improvement and problem-solving activity among the companies in Malaysia. The raw data were obtained from the survey instrument where respondents were requested to rank the importance level and the implementation level of 169 QTT. The individual mean score across of the 169 QTT for the importance level and the implementation level were computed. The result shows the mean score for importance level is range from 6.00 to 6.68 and the implementation level is range from 3.80 to 6.03. Subsequently, the result of the importance level and the implementation level were used as an input to calculate the implementation effectiveness.

4.3 Implementation Effectiveness

QTT implementation effectiveness refers to the comparison of QTT implementation level versus QTT importance level in term of percentage. Therefore, the QTT implementation effectiveness is derived by dividing the mean score of implementation level with a mean score of importance level and multiplies the product by 100%. A low number of effectiveness means the importance placed by the companies have not been translated into practice successfully. However, an implementation effectiveness that higher than 100% can be presumed as an over-focused indication. The result of QTT implementation effectiveness was summarized in Table 2.

Table 2: Implementation effectiveness of QTT.

QTT	Mean Score Importance Level (a)	Mean Score Implementation Level (b)	Implementation Effectiveness (a/b) x 100%
Cause and Effect Diagram / Fishbone / Ishikawa Diagram	6.42	6.03	94%
Check Sheets	6.32	5.93	94%
Histogram	6.41	6.01	94%
Pareto Diagram / Charts / Analysis	6.36	5.82	91%
Cost Benefit Analysis	6.30	5.73	91%
Analysis of Variance (ANOVA)	6.06	5.50	91%
Control Chart	6.36	5.75	91%
Jidoka (Automation)	6.18	5.59	90%
Capability Indices	6.20	5.60	90%
Standard Operating Procedures (SOP)	6.30	5.68	90%
Scatter Diagram / Plots	6.36	5.73	90%
Check list	6.23	5.62	90%
Standard Operations / Work	6.13	5.50	90%
ISO 14001	6.50	5.83	90%
MSA	6.13	5.48	89%
Autonomation	6.17	5.50	89%
Work Flow Analysis (WFA)	6.00	5.33	89%
Total Productive Maintenance (TPM)	6.15	5.46	89%

Affinity Diagram	6.38	5.66	89%
Business Plan / Target / Goals	6.29	5.57	89%
Quality Council	6.14	5.43	88%
Quality Manual	6.14	5.43	88%
Recognition and Reward Systems	6.14	5.43	88%
Supplier Evaluation	6.14	5.43	88%
Supplier Training	6.14	5.43	88%
Single Minute Exchange of Die (SMED)	6.30	5.50	87%
Cause and Effect Analysis	6.50	5.67	87%
Financial Analysis	6.50	5.67	87%
Kaizen	6.46	5.63	87%
Takt Time	6.15	5.35	87%
Individual Training Plan	6.57	5.71	87%
Pie Charts	6.42	5.58	87%
ISO 9001:2000 (Quality Management System)	6.46	5.62	87%
Sticking Dots	6.33	5.50	87%
Activity Based Costing (ABC)	6.33	5.50	87%
Best Practice	6.33	5.50	87%
Hoshin Kanri	6.33	5.50	87%
Process Flow Diagram	6.36	5.52	87%
Cross Functional Teams	6.43	5.57	87%
Gantt Charts	6.36	5.50	87%
High Level Mapping / High Level Process Map	6.17	5.33	86%
Radar Chart	6.17	5.33	86%
Value Added (VA) Analysis	6.17	5.33	86%
Tally Charts	6.17	5.33	86%
Knowledge Management	6.17	5.33	86%
Value analysis	6.17	5.33	86%
Flow Chart / Diagram	6.42	5.54	86%
Generic Pull System	6.00	5.17	86%
Quality Policy	6.14	5.29	86%
Just In Time (JIT)	6.25	5.38	86%
Problem Solving Methodology	6.40	5.50	86%
Work Instructions / Information	6.42	5.51	86%
Cost of Quality	6.13	5.25	86%
Fault Tree Analysis (FTA)	6.25	5.35	86%
SWOT Analysis	6.20	5.30	85%
5 Whys	6.49	5.51	85%
Frequency Distribution / Frequency Plot	6.50	5.50	85%
Replenishment Pull System	6.50	5.50	85%
Stakeholder / Relevant Stakeholders	6.50	5.50	85%
Standardization	6.50	5.50	85%
Heijunka (Level Scheduling)	6.50	5.50	85%
Process Management	6.50	5.50	85%
Time Series Charts	6.50	5.50	85%
Reliability Analysis	6.50	5.50	85%
Customer Satisfaction Survey	6.43	5.43	84%
Data Collection Forms	6.43	5.43	84%
Departmental Purpose Analysis	6.43	5.43	84%
Risk Assessment	6.33	5.33	84%
Validation Testing	6.33	5.33	84%
Setup Reduction	6.33	5.33	84%
Zero Defects Program	6.33	5.33	84%
Stem and Leaf Diagram / Display	6.33	5.33	84%
5S	6.58	5.54	84%
Data Collection Plan	6.29	5.29	84%
Posters	6.29	5.29	84%
Multi Vari Chart	6.20	5.20	84%
Spaghetti Diagram / Charts	6.20	5.20	84%
Non Value Added (NVA)	6.17	5.17	84%
Project Management / Project Management Tools	6.17	5.17	84%
Working Flow Analysis / Work Flow Diagram	6.17	5.17	84%
Basic Statistic	6.17	5.17	84%
Contingency Table	6.17	5.17	84%
Decision Matrix	6.17	5.17	84%

Enterprise Resource Planning (ERP) Systems	6.17	5.17	84%
Impact / Effort Matrix	6.17	5.17	84%
Matrix Diagram	6.42	5.38	84%
Mind Mapping	6.13	5.13	84%
Brainstorming	6.53	5.45	83%
Taguchi Methods	6.00	5.00	83%
Mission and Vision Statement	6.33	5.22	82%
Single / One Piece Flow	6.38	5.25	82%
Quality Costs	6.29	5.18	82%
5W2H	6.36	5.23	82%
Trend Chart	6.22	5.11	82%
Quality Improvement Teams	6.22	5.11	82%
Sales and Operations Planning (S&OP)	6.50	5.33	82%
Critical to Quality (CTQ) Tree	6.50	5.33	82%
Force Field Analysis	6.26	5.13	82%
Confidence Intervals	6.60	5.40	82%
Regression Analysis	6.42	5.25	82%
Concurrent Engineering (CE)	6.33	5.17	82%
Stratification / Stratification Analysis	6.23	5.08	81%
KANO Analysis	6.29	5.12	81%
Visual Controls / Management	6.65	5.40	81%
Graphs	6.47	5.25	81%
p Chart	6.17	5.00	81%
Process Control Plan	6.17	5.00	81%
Stakeholder Analysis	6.20	5.00	81%
Box Plot	6.47	5.20	80%
Solution Selection Matrix	6.22	5.00	80%
Business Process Reengineering (BPR)	6.22	5.00	80%
Process Capability Analysis (PCA)	6.68	5.37	80%
Overall Equipment Effectiveness (OEE)	6.11	4.89	80%
Nominal Group Technique (NGT)	6.25	5.00	80%
Hypothesis Testing	6.26	5.00	80%
X bar and R Charts	6.18	4.91	79%
Piloting / Pilot Testing	6.30	5.00	79%
Correlation Analysis	6.44	5.11	79%
Voice of the Customer (VOC)	6.44	5.11	79%
Descriptive statistics	6.44	5.11	79%
Gage Repeatability & Reproducibility (Gage R & R)	6.63	5.25	79%
Process Decision Program Chart (PDPC)	6.20	4.91	79%
Kanban	6.26	4.96	79%
Self-Assessment Activities	6.33	5.00	79%
Critical to Quality (CTQ)	6.33	5.00	79%
Critical to Quality Characteristics (CTQC)	6.33	5.00	79%
Robust Design / Robustness	6.33	5.00	79%
Process Mapping	6.42	5.05	79%
Value Stream Mapping (VSM)	6.32	4.97	79%
Mistake Proofing / Error Proofing / Failsafing / Poka Yoke	6.22	4.88	78%
Surveys	6.50	5.10	78%
Distribution Analysis	6.38	5.00	78%
Supplier Input Process Output Customer (SIPOC) Diagram	6.32	4.95	78%
Project Charter	6.29	4.92	78%
Questionnaires	6.31	4.92	78%
Failure Mode and Effects Analysis (FMEA)	6.36	4.96	78%
Six Sigma Indicators	6.00	4.67	78%
Matrix Data Analysis Method	6.27	4.87	78%
Pull Systems / Pull Approach	6.44	5.00	78%
Quality Function	6.37	4.93	77%

Deployment (QFD)			
Control Plans	6.35	4.91	77%
Design of Experiments (DOE)	6.44	4.97	77%
Arrow Diagram / Activity Network Diagram	6.23	4.79	77%
Run Charts	6.33	4.87	77%
Simulation and Modelling	6.22	4.78	77%
Sampling / Sampling Planning / Technique	6.40	4.90	77%
Multi-voting	6.38	4.88	76%
Presentations	6.34	4.81	76%
Tree Diagrams	6.38	4.83	76%
Suggestion Schemes / Systems	6.53	4.93	76%
Prioritization Matrix	6.40	4.83	75%
Statistical Process Control (SPC)	6.50	4.89	75%
Monte Carlo Simulation	6.00	4.50	75%
Balance Scorecard	6.46	4.85	75%
Benchmarking	6.43	4.80	75%
Focus Group	6.38	4.75	75%
Systematic Diagram	6.31	4.69	74%
Pugh Matrix / Analysis	6.44	4.78	74%
Interrelationship Diagram / Relationship Diagram / Relation Diagram	6.51	4.80	74%
Cause and Effect Matrix	6.46	4.69	73%
Bar Chart	6.40	4.60	72%
Root Cause Analysis (RCA)	6.56	4.67	71%
Line Balancing	6.44	4.56	71%
Multivariate Analysis	6.17	4.33	70%
Capability Analysis	6.67	4.67	70%
Correlation and Regression Analysis	6.00	4.20	70%
Factor Analysis	6.40	4.40	69%
Non Parametric Tests / Method	6.33	4.00	63%
Regression & Correlation Analysis	6.33	3.80	60%

5. CONCLUSION

This investigation was conducted to find the level of implementation effectiveness of the QTT used within the companies in Malaysia. The implementation effectiveness was calculated based on the perceived of the importance level and implementation level. The data show that the ranking of QTT based on the importance level was varied compared to the implementation level. Thus, it shows that the priority of QTT between practitioner and organization is varied.

The different, possibly happen due to the selection view used by the organization is influenced by the other factors that related to the selection of the improvement methodology. [21] studied the selection of the improvement methodology consist of fashion setting, payoff, strategic fit and organization fit. These selection views are used prior to the deployment of improvement activities [21].

This study found the minimum level of implementation effectiveness was 60% and the maximum was 94%. None of the QTT is over-focus or over than 100% of implementation effectiveness. Total 115 QTT out of 169 QTTs show the level of implementation effectiveness is 80% and above, and only 3 QTTs show less than 70%. These findings indicated that 68% of the QTTs listed in the survey were implemented in the industry as the perceived importance by the practitioners. Table 3 summarized the findings of implementation effectiveness.

Table 3: Summary of implementation effectiveness findings.

Max level	Min level	Mean level	Median level
94%	60%	82%	84%
Number of QTT ≥80% level		**Number of QTT 80%<x≤70% level**	**Number of QTT 70%<x≤60% level**
115 (68%)		51 (30%)	3 (2%)

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