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RESEARCH ARTICLE

Optimizing Quality Tool Selection with Cosine Similarity for Continuous Improvement

Siti Zawani Ibrahim[1], Mohd Amran Mohd Daril[2*], Mohamad Ikbar Abdul Wahab[3], Khairanum Subari[4], Qarna Manan[5], Sobia Irum[6]

[1,2,3,4] Universiti Kuala Lumpur, Malaysian Institute of Industrial Technology, Johor Bahru, Johor, Malaysia
[5] Production Department, Ruffntuff Sdn Bhd, 71309 Rembau, Negeri Sembilan, Malaysia
[6] Department of Management and Marketing, College of Business Administration, University of Bahrain, Bahrain

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***Corresponding Author:**

mamran@unikl.edu.my

ABSTRACT

Making decisions is an inevitable part of any process. Some suggest opting for the choice that minimizes regret because, regardless of how sound a decision may be, risks are always present. Decision-making becomes particularly challenging in areas where quality is critical. In any industry, maintaining quality is essential since products and services ultimately reflect back on their providers. To uphold quality standards, organizations must engage in continuous improvement activities, which include everything from root cause analysis to implementing the best solutions. To ensure these activities are effective, organizations need guidelines to avoid starting from scratch and to follow proven methods. These guidelines often take the form of Quality Tools and Techniques (QTT). However, the abundance of QTT can make it difficult for quality personnel to select the most appropriate ones. This is where rational selection theory becomes useful. By applying one of the artificial intelligence algorithms, Cosine Similarity, this paper explores its feasibility in selecting the most suitable QTT.

INTRODUCTION

Decision often associates with making a choice between several options. It is a selection process whereby decision maker chooses that option over this option. Believe it emotion played a big role in decision making thus result in some decision connected with emotion in some ways. In one study[i] it is said that emotions strongly, foreseeable, prevalently impact decision making. In same study, there are two type of emotion that influence decision making which are integral emotion and incidental emotion. Integral emotions are the emotions that caused by decision itself when decision maker think about the parameter and implications of the decision while the later is emotion that carry by decision maker to the decision that have nothing to do with the decision. Involving emotion in decision making seems like pretty useful, however most of the time rational inference is needed to make sure the decision made is based on logical reason.

Here, rational decision-making theory is applicable. According to Laure and Jean- Pascal, (2011)[ii], rational choice within organization is being construct by 3 pillar which are theory, actors, and tools and through 3 mechanism which are rationality conventionalization, rationality engineering, and rationality commodification. The study conceptualizes rational decision making as performative praxis which refer to flow of activity on how rational decision is made which also means the contribution of realization of theory of rational choice. This research adopts rationality engineering where at the end of the research, a decision-making tool is published that will help quality personnel

make decision. Decision making tools in this research refer to AI- apps that was developed by using attributes of quality tools and techniques. Before going further on the attribute, let understand first what Quality tools and techniques (QTT) is. QTT can be defined individually as quality tools and quality techniques. Quality tools can be defined as device that has a clear role and more focus and usually used on their own meanwhile quality techniques can be defined as more complex device and has wider application as well as require more steps to complete[iii]. Quality tools and techniques can be use in improvement activity as they can act as framework and any organization that go for improvement activity do not have to start from scratch when using quality tools and techniques. In this research, attribute of QTT is being established to differentiate the individual QTT according to its classification.

This research constructs the research framework using attributes of QTT where 5 classifications are being introduced: Categorization, Input, Function, Output and Demographic. These attributes belong to each different QTT. However, due to high number of QTT, the selection of most fit QTT to be use become difficult. This is when the need of AI model become crucial to help quality personnel choose the right QTT.As mentioned above, attribute of QTT is being used to develop the apps. Here, researcher utilized one of the algorithms in Artificial Intelligent which is Cosine Similarity as an algorithm for the apps to be able to predict the suitable QTT. Generally, cosine similarity is useful to measure the similarity between two documents[iv]. This means there are two documents, one is reference and another one is document that need to be compare. Reference document is a document that is assigned as reference to obtain the similarity between two documents while the second will be compared to reference to get the similarity with the reference. The similarity between the two documents is obtain through cosine similarity. In this research, reference document is referred to the data obtain from quality mapping whereas second document is from end user who use the apps.

In addition to high number of QTT, this research also addressed the limited time and resource for quality personnel to find out about attribute of QTT. As the attribute is the identifier for QTT, it is crucial for quality personnel to know details about the attribute. However, most of the time the job roles are the top priority and there is no time to do research about attributes as well as QTT and this led to quality personnel just use any QTT limit to their knowledge only. Besides, current selection model from previous research did not have the prediction feature[v] and offer this research the opportunity to improve the previous model. Apart from that, this research aims to develop a set of training data for AI model to predict the QTT as well as design an algorithm that suitable for development of AI model.

2 Literature Review

This research adopts Integrative Literature Review (ILR) to find the information about attributes of QTT. According to one study[vi], ILR is a form of research that reviews, critics, and synthesize representative literature on topic in an integrated way such as new framework and perspective on the topic are generated. As the research topic grow, there is expanding on the knowledge of the topic. In another study[vii], it is said that ILR is very useful when existing research is in need for improvement and has not been fully systematically analyze. This research use one main reference from a study of same topic[v]. However, this reference study does not have prediction feature for the selection model. Through ILR, there are about 800 attributes found. From this number, the classification based on logical group is made as mentioned in previous section which are Categorization, Input, Function, Output, and Demographic. There are 13 paper that provide the information related to QTT definitions in which 4 paper defines QTT separately; tool and techniques, 3 paper only define the tools and 6 more paper discuss the connection of QTT with methodology. There are many methodologies offered with a set of quality tools and techniques in each step of improvement action[viii]. Due to this, it is safe to say that QTT can be found within methodologies use in improvement activities.

Table 1: Paper that explain tool and techniques separately

Authors	Title	Source Title
Ilma, Santi, Murshid, 2012	Application of Quality tools and techniques in hospital: Case study at Banding, Indonesia.	Conference Paper; 3rd International Research Symposium in Service Management
Amran. Khairanum, Aisyah, 2020	Development of conceptual model of the factors that leading to problem of the using the quality tools and techniques: A current review.	Journal of Critical Review
Augusto and Dario, 2008	Comparing the use of method, techniques, and tools promoted by quality management systems and programs.	XIV International Conference of Industrial Engineering and Operations Management
Fonseca, Lima, Silva, 2015	Utilization of Quality Tools: Does sector and size matter	International Journal for Quality Research

Table 2: Paper that explain only definition of quality tools

Authors	Title	Source Title
Dusco, Mirco, 2008	Practical application of quality tools	Quality Festival 2008. 2nd International Quality Conference
Bojan, Milan, Sarcocevic, 2013	Quality tools in project management	7th International Quality Conference
Samuel and Paolo, 2019	The importance of quality tools in the health environment	International Journal of Advanced Engineering Research and Science (IJAERS)

Table 3: Paper that explain the connection of QTT with the methodology

Authors	Title	Source Title
Starzynsca, 2014	Practical application of quality tools in Polish manufacturing companies	Organizacija, volume 47
Fabio et all., 2013	On the use of quality tools: A case study	Proceedings of the World Congress on Engineering 2013.
Vivek, Sandeep, Sharma, 2017	Analyzing the barrier affecting the effective utilization of quality tools and techniques using integrated ISM approach	Management Science Letter
Shafiqah, Amran, Khairanum, 2020	A study of critical success factors of quality tools and techniques implementation: A current review	Journal of Critical Reviews
Amran et all., 2020	The implementation of effectiveness of quality tools and techniques	International Journal of Advance Trend in Computer Science and Engineering
Manjeet and Rajiv, 2017	Quality tools and techniques: factors influencing success and failure in manufacturing enterprise	Proceeding of the 17th ISME Conference

As per mentioned above, with increasing number of QTT, selection become more complex and QTT need to breakdown into simpler meaning so that it can be use easily. In the main reference[v], QTT is being express based on characteristic of QTT. Characteristic of QTT can be explained as attribute that own by individual QTT that differentiate them from one another and act as QTT identifier. From all reference, there are 856 number of attributes that has been explain in various term, but none explain about selection method other than the main reference but never mention about selection through AI algorithm.

Categorization, Input, Function, Output, and Demographic are the logical group or classification that contain common attributes. This classification act as framework and mainly derive from the main reference and another one reference[ix]. As attributes are dynamic, there will always increasing in number or altered follow situation in improvement activities, and that said QTT also increase or changed as well.

This research aims to develop an apps that able to select QTT using prediction. Generally, QTT selection is done manually through matrix diagram. Nevertheless, the main reference[v], had attempt

and success in developing Intelligence Decision Support System (IDSS) by using a set of programming to choose suitable QTT. There are few studies about selection of QTT in improvement method.

Table 4: Paper that explain about QTT selection

Authors	Title	Source Title
Mirko et all., 2019	Basic quality tools in continuous improvement process	Journal of Mechanical Engineering
Natcha, 2007	Selecting quality management and improvement initiative: case studies of industries in Thailand	Thesis for Doctor of Philosophy

Research done by Mirko et all. only explain selection using conventional matrix based on its application in PDCA cycle, Six Sigma, and Lean Six Sigma whereas research by Natcha using Multi Criteria Decision Making (MCDM) as selection method. MCDM used weight sum method to evaluate the criteria and reflect their important.

This research explored the subfield of Artificial Intelligent which is machine learning. Generally, machine learning provided the statistical tools to explore and analyze the data which consist supervised, unsupervised and reinforce learning. This research used supervised learning algorithm which is Cosine Similarity. Supervised learning is where a machine is being train with labelled data. According to one study[x], supervised learning is a process where with input given, the expected output is known. The main function is to build an estimator capable to predict the label of an object by given set of features. Cosine similarity is one of the supervised learning algorithms and can be expressed in below formula[xi]:

$$\cos\theta = \frac{\vec{a}\cdot\vec{b}}{\|\vec{a}\|\|\vec{b}\|}$$

Basically, this algorithm is based on dot product and length of vectors. Cosine similarity is the measure of resemblance between things that being compared with the use of vectors. A vector is a quantity with two independent properties which are direction and magnitude. The orientation of the line segment is its direction, and the length is its magnitude. Dot product is the result of multiplying a vector by itself or another vector and taking summation. Dot product can illustrate the direction of the vector. For example, dot product equal to 0 indicate that the angle between two vector is exactly 90°. An angle of 90° means that cos Ø equal to 0 so the vectors point to perpendicular direction. When taking the square root, dot product between vector itself give information about length. To put it simple, above formula is a dot product/ length product ratio that said, cosine similarity is the measurement of direction- length resemblance between data sets represented as vectors[xi]. Another study[xii] explain that cosine similarity quantifies the resemblance between two sentences or document in term of value within the range of [-1,1]. Furthermore, one study[xiii] state that cosine similarity is a measure of similarity between two vectors that measure the cosine of the angle between them. Two vectors with same orientation have a cosine similarity of 1. Other study[xiv] also

state the same fact which is similarity between two documents can be derived by calculating cosine value between two document's term vectors.

3 Methodology/Materials

There are five phase that need to be done to finish this research. The first phase starts off with identifying problem, formulation of research objective and research questions. Besides, to conduct literature review, this research adopted Integrative Literature Review (ILR). Through this method, researcher has summarized the definition of QTT, list of QTT, attribute of QTT, review the classification model of QTT attribute and studied the QTT selection method. From literature review, researcher able to find out the research gap which is the IDSS model from the main reference and had the opportunity to improve the model.

The second phase focusing more on development of classification model. To construct the classification model, researcher use total number of 716 attribute that make up the 5-classification group. To develop the training data for apps, QTT mapping was conducted. QTT mapping is being conducted by survey through consensus group techniques as one of the common tools to collect data from survey. The purpose of the QTT mapping is to identify the attributes of each QTT. To validate the QTT mapping, expert opinion is needed. Expert opinion served as an instrument to get most reliable opinions, judgement, and consents. The experts that have experience using QTT and currently work as academician and continue practicing the QTT are chosen. Through consensus group techniques, criterion level of agreement is uses to decide the statement of discussion. In this research, statement referring to the list of attributes and the list of QTT. The expert must decide the attribute of each QTT. To assist the expert, the description of the attribute is provided, and template of mapping is used to assist expert map the attributes with QTT.

Next is phase three. The main activity in this phase is the development of AI model that translated to web-apps format. Here, the 5 classifications (Categorization, Input, Function, Output, Demographic) will be translated into computerized system through Python as scripting language. As for database, the data from QTT mapping is being stored in SQL that act as standard programming language employed in relational database management. For algorithm, this study used cosine similarity. As previously explain in previous section, cosine similarity algorithm can be uses to find the similarity between referral document and document need to be compared and able to predict the next output. The flow for prediction model is illustrate in figure 1 below. This phase also conducts black box testing to check the apps functionality. For the black box testing, the required function for the apps become the criteria for the testing.

In phase four, the main activity is on acceptance testing of the apps. This testing is done by user that involve in improvement activities. To conduct this test, case study is adopted. In this research, single case study with single unit of analysis is enough and suitable choices because the purpose of the case study being use is only to test the apps in actual improvement activities. Hence, single organization and single team is enough to see the function of the apps. After the case study subject is chosen, then User Acceptance Testing (UAT) is conducted. UAT is the process of verifying a solution works for user[xv]. It is the final phase of the software testing process. During this test, actual software users test the software to make sure it can handle required task in real- world situation, follow the requirement. This testing can resurface the defect or errors in the software and reveal issues that are efficiently additional to or changes to the requirements[xvi]. In this study, scale was used to measure the apps meet the requirements. Overall, the scale is about agree or disagree toward the apps. If the level passed the certain number, then the apps is considered accept by user. To conduct UAT, procedure such as team formation, planning, design the test, implement, evaluate, and decision making need to follow as indicate in figure 2 below.

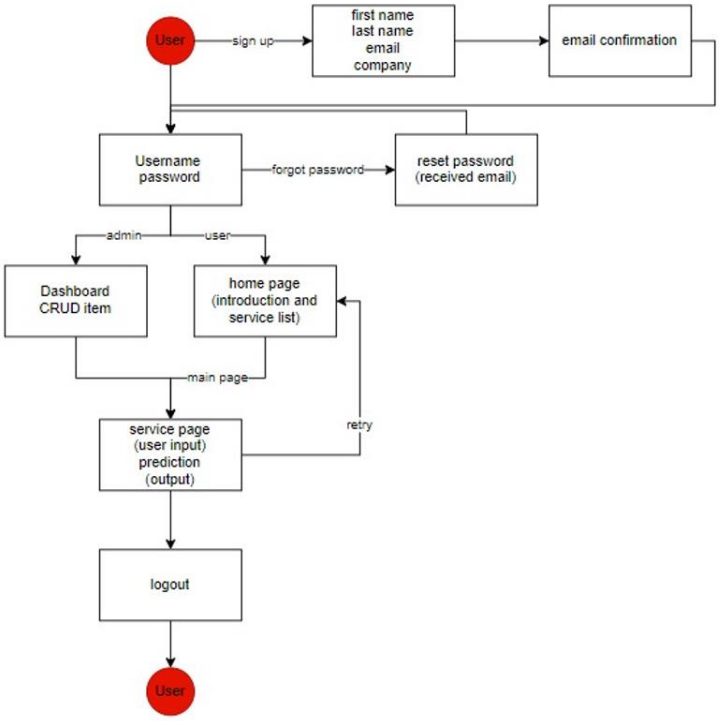

Figure 1. Flow for prediction model

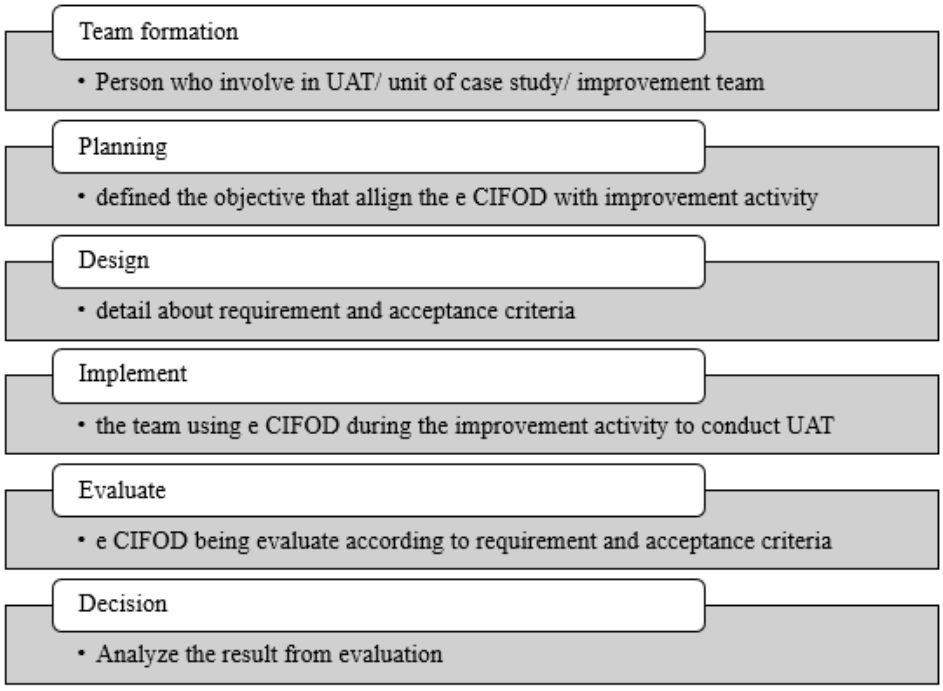

Figure 2. Procedure for UAT

Data collection method for case study is through interview. As there is team in UAT, then interview is suitable to do. The interview is being conducted through consensus group techniques. Criterion level of agreement is uses to decide the statement of discussion. In this process, statement referring to the requirement and acceptance criteria. The experts must decide the level of agreement. According to one study[xvii], the statement needs to reach the level agreement of 75% of the expert vote on the statement. The overall process of the techniques is illustrated in the figure below.

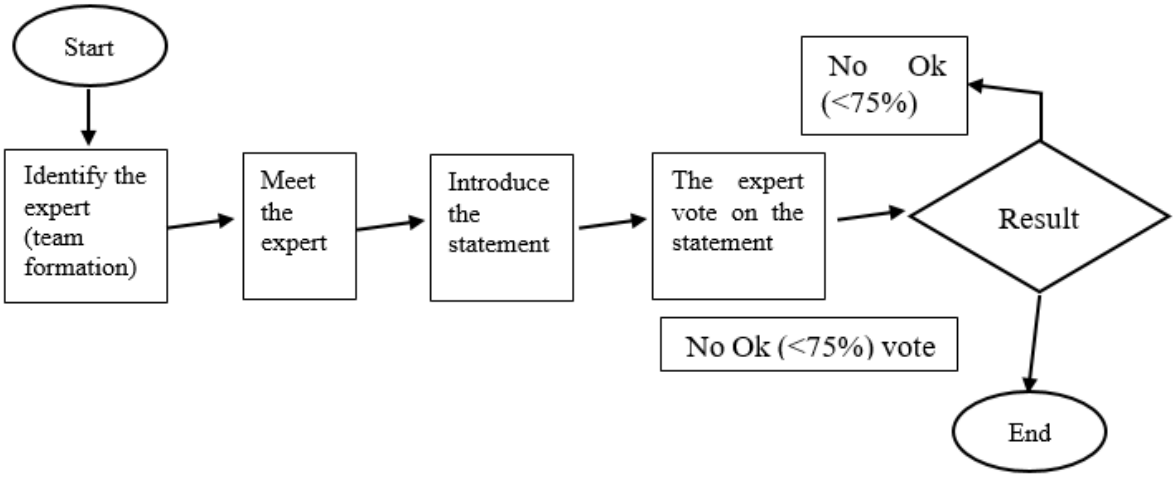

Figure 3. Process flow of consensus group techniques

Data analysis in case study is divided into general analytic strategies and analytic techniques[v]. To conduct data analysis in case study, it important to have general analytic strategy. Since UAT using consensus group techniques, the level of agreement among team member can be measured. Kendal coefficient of concordance is used to analyze the data. This analysis can produce result whether consensus has been reached, consensus is increasing and show the relative strength of consensus. SPSS is used to find the Kendal coefficient.

Last phase is phase five. In this phase, major activities are result of the analysis, the conclusion of the study and the recommendation for future research. For result of the analysis, researcher will show the evidence of findings based on method discusses in previous chapter. In conclusion researcher will show the findings based on research questions, research objective and pin out the implication of the study. Lastly, researcher will list out the limitation of the study and suggest future recommendation.

4 Results and Findings

The result of QTT mapping was obtained from consensus group techniques that deduce from expert opinion. As previously mentioned, there are five classification group. Under these five groups there are 13 subgroups 1, 6 subgroups 2, and 709 attributes. Under categorization, there are four subgroups 1 and 2 subgroups 1 with total attributes of 30. Second classification which is input has 2 subgroups with attribute of 5. Next is output with 3 subgroups 1 and 2 subgroups 2 with attributes of 46. Demographic has 3 subgroups 1 and 2 subgroups 2 with attributes of 46. Lastly, for function there are 2 subgroups 1 and 2 subgroup 2 with attributes of 582. Framework for QTT attribute can be illustrate in figure 4 below.

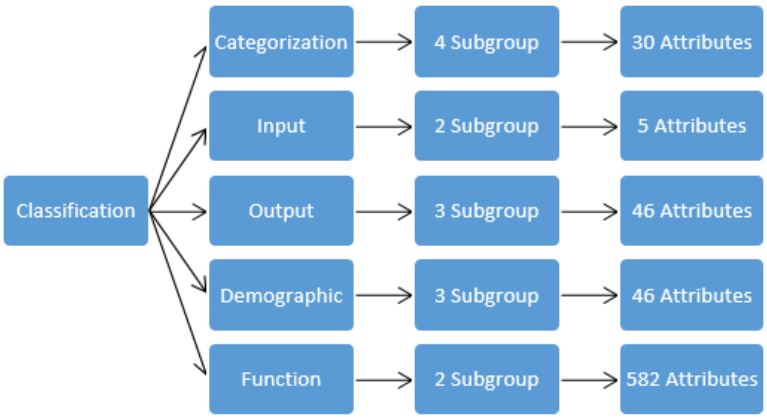

Figure 4. Attribute Framework

From this classification, these attributes are being mapped with QTT. Example for QTT mapping is show in figures below.

QTT Attributes		Pareto Diagram
Categorization	Type of QTT	Basic 7 QC Tools
		Statistical QTT
		Quantitative QTT
		Prerequisite QTT
	Place of QTT in PDCA cycle	Plan
		Check
	Place of QTT in DMAIC cycle	Measure
		Analysis
		Improve
		Control
	Nature of QTT	Tools
		Techniques
		Methodology

Figure 5. QTT Mapping for Categorization

QTT Attributes		Pareto Diagram
Input	Type of information needs by QTT	Numerical data
		Numerical analysis
	Type of input data required by QTT	Numerical

Figure 6. QTT Mapping for Input

QTT Attributes		Pareto Diagram
Output	Intangible result	Analyze
		Classifies
		Organizes
		Prioritize
	Tangible result	Chart
		Numerical comparison
	Impact	Medium term
		High level

Figure 7. QTT Mapping for Output

QTT Attributes		Pareto Diagram
Demographic	Skill or experience of user in problem solving	Novice
	System level	Line
	Sectors	Banks
		Credit function
		Manufacturing industries
		Production

Figure 8. QTT Mapping for Demographic

QTT Attributes		Pareto Diagram
Function	Activity required QTT	Supplier improvement activities
		Internal customer focus
		Quality activities
		External customer activities
	Purpose	Process based
		Control and measure
		Understanding the problems
		Identifying relationship

Figure 9. QTT Mapping for Function

5 Conclusion

To summarize, researcher successfully identify the list of attributes and come out with the classification. Besides, researcher able to collect data through QTT mapping and able to provide data training for apps. This will help user to identify individual QTT and aid in QTT selection. Through this research, quality personnel can adopt the apps as aided tool to assist in problem solving or improvement activity.

Future research can explore on another topic to recognize QTT like QTT used based on problem happen in manufacturing industries. The new formula may initiate from this point onward and can be used to assist in improvement activity.

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