Performance Measurement Model for Malaysia Higher Education Institutions using Knowledge-based System Approach

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ABSTRACT

Over the last few years, Performance Measurement (PM) becomes a valuable tool to measure the performance of an organization. The main reason for measuring the performance is to assess the current position of the organization and help managers to create a better strategy. In the education sector, there are some organizations provide a system in measuring performances for Higher Education Institutions (HEI) performances like Quacquarelli Symonds (QS) World University Rankings, Times Higher Education World University Rankings (THE), The Discipline-Based Rating System (D-SETARA) and Malaysian Research Assessment Instrument (MyRA). This instrument makes almost all HEI in the world strive to achieve the performance target. However, the uniqueness and complexness of the HEI's process make the current PM is difficult to map with the existing ranking system. This problem will not only burden the HEI but also may cause the actual target cannot be achieved and may even lead a bad impression to the final result. Since the goal is not equivalent to the strength, staffs of the HEIs need to take and do works that exceed their limit. Thus, this research has been propagated to create an enhance performance measurement model that caters the need of HEIs. The primary purpose of this model is to assist institution's top management in controlling and gauge the performance achievement of Higher Education Institutions (HEIs) in Malaysia based on individual staff's input that can contribute to the overall institutional performance. This research using qualitative case study methodology with Knowledge-Based System (KBS) development. The finding of this research will give advantages to the HEI's in Malaysia in managing and controlling the institution performance. With the successes of this model development, this research able to help most of the HEI, especially in Malaysia to manage and monitor performance achievement in the future.

Keywords: *Higher Education Institutions, Performance Measurement Model, Knowledge-Based System.*

I. INTRODUCTION

Strategic planning is a process in which top management analyses and identify the objective and goal of the organization to relate and achieve the planned vision for further achievement. It is also known as a set of processes undertaken in order to develop a range of strategies that will contribute to achieving the organizational direction [1]. In the middle 1960s, strategic planning start overwhelms, and from there all leaders start thinking that it can become one of the best ways to implement the strategic plan and devise in order to compete in the business sector [2]. Therefore, this indicates that organizations need to take the lead in developing a strategy that will help the organization achieving goals and objectives set by the organizations [3]. However, a strategic plan cannot be achieved by only applying them alone; some elements need to embed. Dyson (2000) explained in his paper, there are many elements that is needed in order to develop an effective strategic plan, and performance measurement is one of them. At the same time, the awareness of some potential benefits of performance measurement has led to the need for improving the understanding of the impact on strategic planning [1].

Over the last few years, Performance Measurement (PM) becomes a valuable tool to measure the performance of a company. The main reason for measuring the performance is to assess the current position of the organization and help managers create a better strategy [4]. Therefore, applying performance measurement to some extent will give an impact in developing strategic planning. Initially, PM was only used in the business sector, but after getting increasing attention from another sector, PM also being applied in healthcare [5] and [6], public sector [7], construction [8] and even in education [9].

In the education sector, performance measuring system like Quacquarelli Symonds (QS) World University Rankings, Times Higher Education World University Rankings (THE), The Discipline-Based Rating System (D-SETARA) and Malaysian Research Assessment Instrument (MyRA) makes universities in the world strive to achieve the performance target. As the result, each university's administrator begins to place more emphasis on their performance measurement plan to ensure that they are able to perform well in the ranking system.

All universities ranking systems will release the final results at the end of each year. Before universities get their final results, they need to submit all required information (according to the specific indicators) prior to being evaluated. HEI's administrator usually simulate their data to estimate their performance according to the ranking. From there, they can gauge their performance and take necessary action to improve their institution's performance. Therefore, this paper is aimed to propose a model that can guide the HEI's administrators in measuring their performance and also to monitor and gauge the performance achievement of Higher Education Institutions (HEIs) in Malaysia based on individual staff's input that can contribute to the overall institutional performance.

II. BACKGROUND OF STUDY

Nowadays, performance measurement is an essential thing for many sectors to monitor their performance. Performance measurement model (PMM) like the Balanced Score Card and Dashboard often used in measuring the performance. Balanced Score Card and Dashboard are the models where most of the company in the world used to control and gauge the goal they want to accomplish. There are few key elements that always be considered in the performance measurement models, such as financial perspective, customer perspectives, internal environment and staff satisfaction. Staffs play a vital role in the organization. The contribution and commitment from the staff able to improve the organization performance. However, some of the PMM did not emphasize on measuring the staff contribution in improving the performance. The element is there but it is not really measuring the individual staff's performance.

PMM is also being applied in the higher education sector to help the institution to monitor their performance. In the HEI sector, it has a lot of departments, and consist of many staff's contributions in many parts like the research area, social area, and educational area. Although the current PM is not based on individual performance measurement, these models are still being used but with some modifications to suit the environment. Therefore, to get the better achievement in the institutions, the PMM should also able to measure the performance based on the individual achievement so that the achievement can be as a collective achievement that able to improve the overall performance.

Moreover, most of the performance ranking system instruments consist of features related with staffs, and it is essential for administrators to consider the number of active staffs that will contribute significantly to the achievement of the institutions. Some of the HEI's strategic plan is not focusing on the real strength of the institutions based on the number of active staffs, but they included all staffs without considering staffs who may not be able to give a contribution in their institution. The complexness of the HEI's process makes the current PM difficult to map with the existing ranking system. This problem will not only burden the staffs but also may cause the actual target cannot be achieved and may even lead a bad impression to the final result. Because the goal is not equivalent to the strength, many staffs need to take and do works that exceed their limit. In addition, some of the method used is not able to measure the performance so the effectiveness in applying the model cannot be guaranteed. With a lot of performance indicator in ranking system, many aspects need to be considered and monitored before the performance can be measured.

II. RELATED WORK

Numerous studies and research have been conducted to investigate the performance measurement. Since performance measurement has many problems domain, therefore, many techniques and models were used. 'Performance measurement is a process by which an organization monitors important aspects of its programs, systems, and processes' [10]. The instruments used to measure the performance are vary; QS Ranking and THE Ranking are the most famous global universities rankings where most of the universities in the world take part in the ranking systems while D-SETARA and MyRA are ranking systems used in Malaysia.

A. QS Ranking

Quacquarelli Symonds (QS), World University Rankings, is an annual publication ranking universities that help students compare the information of top universities around the world [11]. They rank all the universities based on six performance indicators. Each indicator provides a different value in calculating the overall score for each university. Four of the indicators are based on data from its university and two are from a global survey taken from 40% of Academic reputation

and 10% of Employer reputation.

B. THE Ranking

The Times Higher Education World University Rankings (THE) is the ranking that measures the performance of global universities, including all aspects of teaching, research, knowledge transfers and international outlook [12]. They use thirteen (13) performance indicators to provide a comprehensive and balanced comparison for all universities around the world. THE divided their thirteen (13) indicators into five (5) areas.

C. D-SETARA

The Discipline-Based Rating System (D-SETARA) is a rating system used to assess the quality of teaching and learning in Higher Education Institutions (HEIs) in Malaysia [13]. Before D-SETARA, SETARA been used by MQA since 2006, in 2012 D-SETARA was introduced as an improvement of the system in which D-SETARA is more focused on four clusters of disciplines which are: Engineering; Medicine, Dentistry and Pharmacy; Health Sciences and Hospitality and Tourism.

D. MyRA

Malaysian Research Assessment Instrument (MyRA) is a system developed to assess the research capacity and performance of all Higher Education Institutions (HEIs) in Malaysia [14]. MyRA consists of nine sections with 52 different indicators to measure the university performance. Since MyRA is new in Malaysia, the indicator always changes and added year by year to meet the performance requirements.

There are several model and framework proposed by other researchers in measuring the performance in the higher education sector like Performance pyramid, Results and determinants Framework, Balanced Scorecard and Performance prism [15].

a) Balance Scorecard

Balanced Score Card (BSC) is a performance measurement model proposed by [16], [17]. BSC helps the management lookup the university perspective and translating the vision and mission of the university into action in four perspectives; customer perspective, internal perspective, innovation and learning perspective, financial perspective. University can survive in a competitive environment if they can use BCS to analysis their weakness, strength, opportunities and threat [18]. By giving information from four different perspectives, the BCS helps in minimizes information overload by limiting the number of measures used [13].

b) Performance Prism

Performance Prism is firstly proposed by [19] and commonly used in business and marketing. Nowadays, performance prism also being applies in the educational sector. This model measure performance from five facets. First is stakeholder satisfaction where universities have to identify the target group and to identify their needs, second is stakeholder contribution where its required contributions from the stake-holders to preserve and develop the capabilities, third is strategies ; planning the actions which universities have to accomplish in order to satisfy the users , forth is processes ; the need for processes for improvement and the last is capabilities where needed capabilities/ skills for enhancing the processes [15],[19], [20].

c) Performance Pyramid

Performance pyramid is also known as Strategic Measurement and Reporting Technique (SMART) Pyramid is proposed by [21]. The purpose of this model is to connect the university's strategy with its progress by translating objectives from the top down and measures from the bottom up. Performance pyramid measures performance across nine dimensions (corporate vision, market, financial, customer satisfaction, flexibility, productivity, quality, delivery, cycle time and waste) given the fact that organizations operate at different levels and have different aims [15]. Pyramid proposed by (Cross & Lynch, 1989) consist of nine dimensions and have a four level.

IV. RESEARCH METHODOLOGY

This research is aimed to develop a new model in improving the HEI's performance, especially in Malaysia based on the staff's contribution. This research is a qualitative case study research. One of the public universities in Malaysia will be use as a case study to conduct this research. The researchers need to conduct the meeting with the focus group and do the interview session with the specific target population to get the full understanding of the current problem. The personal opinions and thoughts need to be collected from an expert, and interviews from the specific people need to be done. As it is involved with personal opinion, the survey instrument must be in an open question so that it will make the target sample easier to answers the question based on their preferences.

There are four main phases in the Research process, which are the Investigation phase, Design Phase, Implementation phase, and Validation phase. Every each of phases consists of different types of activities and

then will be explained below.

A. Investigation Phase

Investigation phase consists of two activities, namely identify problem and reviewing literature review. The detailed information of those two activities are as below;

a) Identify Problem - Identifies problem activities is to define the research problem and to set up the objective based on the domain of this research.

b) Reviewing Literature Review - The process after identifying the problem is exploring the information related to the research domain — all the details that linked to this study already presented in the Literature Review.

B. Design Phase

Next is the Design Phase. This phase is the process of identifying the purpose of this research and the way how this research is conducting the data collection and analysis methods.

a) Specifying the purpose

This activity shows the relationship between the research problem and the research question. The approach is taken, and the analysis process in conducting the process also be included in this activity.

b) Collecting Data

Before developing a proposed performance measurement model, data needs to be collected and evaluated before being used as a reference. Then, the selected information will be used to create the model. After completing the model, a prototype will be designed to test the effectiveness of the model.

c) Analyzing data

There are three categories in analyzing data; data analysis, sampling and location.

c1) Data Analysis - After the data collection process is done, the data will be analyzed. Data analysis need to be done to identify and to obtain only essential data. Not just that, but it also helps the process to determine which attributes more important than others. Data analysis also is conducted on data obtained from the inter-view and expert opinions. Qualitative Data Analysis is used as an approach.

c2) Sampling - This research chooses a public university in Malaysia as a targeted institution and chooses the Malaysian Research Assessment Instrument (MyRA) as the research sample. The data will be collected from the personal institutional data and only restricted to this research. This research uses Judgmental sampling to select the sample.

c3) Location - This research was undertaken in Malaysia. One of the public universities in Malaysia will be the base in conducting this research, including conducting the meeting, interview, and developing the model.

d) Research Instrument

The case study could be done by having multiple sources of evidence, which ensure that the study is as robust as possible [22], [23]. This study takes data from three types of sources, which are group meeting discussion, expert interview, and past data. Every data taken needs to be reviewed several times as it is essential information.

C. Implementation Phase

Implementation Phase is a phase that the process of development of the model will be conducted. It has two activities, namely Designing Proposed Performance Measurement Model and Develop Prototype.

D. Validation Phase

Validation phase is the phase where the model will be tested to identify the effectiveness of the model. Triangulation techniques will be used in this validation process.

V. PMM USING KBS APPROACH

Knowledge-Based Performance Measurement Model (KBPMM) is a model that is developed to measure the institution's performance based on staff contributions. It consists of four phases starting from phase A until phase D. The knowledge-based system is used as a primary approach, but in every phase comprises a different type of techniques used. [24] stated in their paper that there are three reasons why KB is used to design the PMM. First, most of the performance variables are usually involved in the successful implementation of Performance Measurement System (PMS), and the relationship between them is quite complicated. Secondly, the needs of the supporting tools that able to keep the consistency and validity in decision making for improving the performance. Thirdly, the benchmarking process in identifying competitiveness also has to be facilitated by appropriate tools.

The KBS is applied to make the PMS valid, consistent, and practical for implementation. The use of the KBS can be considers as the medium to interact with users appropriately and help the user in the decision-making process. Supported by [25], they agreed that the uses of KBS in Performance Measurement could become a powerful and versatile

tool for conducting and controlling performance measurement. This model also uses two additional techniques which are Full-Time Equivalent and Competitor Analysis. The uses of the different techniques are to enhance the effectiveness of the model when being applying in the real situation. Fig.1 shows the diagram of the KBPMM and the description of every phase will be explained in subsections follows.

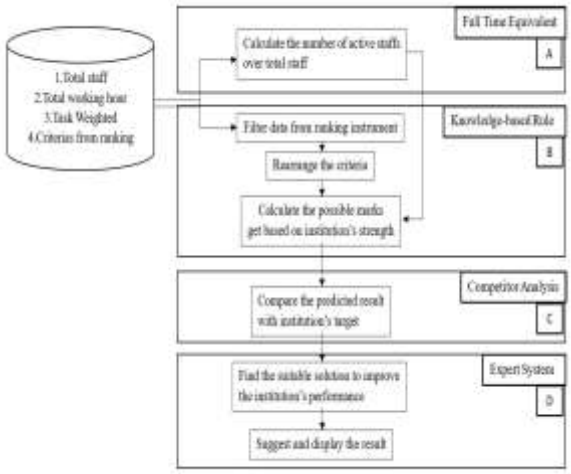

Fig. 1. Proposed Performance Measurement Model (KBPMM)

A. Phase 1 (Full Time Equivalent - FTE)

The purpose of FTE is to measure how many full-time employees they have, along with the number of part-time employees that can be translated into full-time terms [26]. But in this research, FTE is used to calculate the number of staffs over the total number of staffs in the institution that can contribute to a specific task. In the recent study on FTE, [27] found that the formula to calculate the FTE is by using the formula (1).

$$Z = N_S \times T_H \times T_W \times T_{WY} \quad (1)$$

To get the formula (1), firstly let Z is a total working hour for staff where N_S represent to the total number of the staff while T_H , T_W , T_{WY} represent the total number for a total working hour, a total number of a weeks and the total number of the weeks per year. After getting the total working hour for all staffs, Z need to be divided by 2080 to get the FTE number. Let 2080 represent as Y.

$$FTE = \frac{Z}{Y} \quad (2)$$

The number of 2080 is a fixed number to calculate FTE for a year. The formula to get 2080 is as below.

$$Y = 8\,hour\,a\,day \times 5\,day\,a\,week \times 52\,week\,a\,year \quad (3)$$

The full formula to calculate FTE number for total active staff is as below;

$$FTE = \frac{N_S \times T_H \times T_W \times T_{WY}}{Y} \quad (4)$$

B. Phase 2 (Knowledge-Based)

Next process is categorizing all the attributes in the ranking instrument system into three categories; important, less important and not important. In this phase, the Knowledge-Based Rules (KBR) will be used to rearrange the attributes. The reason is to differentiate the attributes so that the system can identify which attributes able to contribute in improving the institution's performance. According to [28], KBR is suitable to be used if the system needs to use many experts' knowledge and be grouped at one platform. Besides, KBR also useful to be applied if the expertise is to be stored for future use. Every ranking instrument system has different types of attributes with different scores. So, it is crucial to identify the importance of each attribute that can contribute to the final result. After the model finishes categorizing the attributes, the next process is to calculate the predicted marks for every attribute in the ranking instrument. The predicted marks are based on the number of FTE for each of the attribute. The data will be taken from the database after phase A completed the process. Firstly, the FTE formula from Phase A is used to calculate the overall FTE. Then, to calculate the predicted score for the attribute, the formula below will be used.

$$predicted\ score = \frac{\left[\frac{benchmark \times total\ FTE}{total\ number\ of\ staff}\right]}{benchmark} \times benchmark\ score \quad (5)$$

C. Phase 3 (Competitor Analysis)

After categorizing and calculating marks for all attributes, the next process is to compare the FTE result from phase B with the current achievement. The reason why the result needs to compare is to analyses the actual strength of the university for making sure that they can improve into better achievement. To compare these two results, the Competitor Analysis approach is used. Competitor analysis is usually applied in a marketing strategy plan to identify the strength and weakness of the competitor with ours. But in this research, this approach will be used to compare the strength and weaknesses of the current university's achievement and predicted performance achievement based on staff's contribution.

As this approach is in the marketing plan, so for this research, this technique will be modified to ensure that it is suitable to be used in this study. We only compare the current university's achievement with predicted performance achievement based on staff's contribution then identify the different value between them.

D. Phase 4 (Expert System)

The last part of the model is by using an Expert System to identify and suggest the suitable solution in order to improve the university's performance based on the current performance and predicted performance achievement based on staff's contribution result. An expert system is a computer program that attempts to mimic human experts by the system's capability to render advice, to teach and execute intelligent tasks [28]. This process is to suggest the most suitable results that match with targeted input. At the end of the process, the system will display the result in a graphical interface to assist the university in planning their future performance. The formula below is used in the model to identify and find the most suitable solution in improving the university's performance achievement:

$$\begin{aligned} &if\ a = x\ AND\ b = y\ AND\ c = z\ AND\ d = n\ AND\ e = w\ then\ f = Z \\ &where; \\ &\quad a = attribute\ name \\ &\quad b = criteria's\ category \\ &\quad c = action \\ &\quad d = priority \\ &\quad e = limitation \\ &\quad Z = solution \end{aligned} \tag{6}$$

VI. VALIDATION PHASE PROCESS

The validation phase is the phase where the model will be tested to identify whether it can meet the research objective or not. The purpose of conducting validation and evaluation of the proposed model is to make sure that the model is able to be used in measuring the institution's performance based on staff's contributions. The techniques used to validate the model is by using Triangulation. The primary purpose of Triangulation is to increase the credibility and validity of the result. The use of triangulation can increase confidence in research data, finding innovative ways to understand the phenomenon and can provide a clearer understanding of the problem [29]. There are five types of triangulation, namely data triangulation, investigator triangulation, theory triangulation, methodological triangulation and environmental triangulation. This validation process used theory triangulation. Theory triangulation collects the data from multiple perspectives and gives the advantages to the research to gain a broader and deeper analysis of findings [30]. This research use experts' views from differences perspectives to test the effectiveness of the model when being implemented into the system. The expert panels are chosen based on several criteria to evaluate and test the model in the system. Table- I shows the positions of the three selected experts chooses to evaluate the model.

Table- I: Position of the selected experts

Expert	Position
E1	Director of Strategic, Quality & Risk Management Center
E2	Deputy Director of Strategic, Quality & Risk Management Center
E3	Manager (Cooperative Center - COE) Research and Innovation Management Center

The questionnaire form regarding the current issue will be distributed to the experts. It consists of two types of questions - general questions and specific questions. These experts have given a set of questionnaires to review the model and to test the effectiveness of the KBPMM in PMS. The summary of the validation findings from the expert view approach are discussed as below.

First of all, the experts were being asked about what is the current approach taken by that selected institution on improving the institution's performance in a research area. E1 stated that currently that institution used strategic planning and MyRA to control the performance. While, E2 said that there are six themes has been applied for that institution to manage the performance; which are academic excellence, research reputation, student excellent, community and industry relation, staff competence and the last is financial sustainability. In E3 perspective, the expert said that the current approach used to improve the university's performance on research area is by giving incentive to researchers producing high impact publication as motivation, besides developing and implementing the vision, mission and objective. All of them stated that there are system/alternatives used to help in controlling the current university performance, but the current system/alternatives used are not enough in helping that institution in improving their overall performance.

In order to test the effectiveness of the KBPMM, the PMS has been developed and the KBPMM being implemented into PMS. Then, the PMS were gives to the expert to test. They need test the PMS to identify the

effectiveness of the KBPMM when being implemented into it. The purpose of the questions is to identify whether the solution produced by the PMS is suitable and can help the institution in improving the performance. The PMS should run simultaneously the same with the flow of the KBPMM so that the objective of this process can be achieved. The PMS gives the solution on how to improve the performance based on current achievements, then the expert need to determine whether the solution provided by the PMS is applicable and suitable to be used in order to improve the performance. All the solution suggested are auto predicted by the system based on current achievement and predicted achievement.

Table- II shows the percentages of the satisfaction and acceptance of the final outcome based on the expert's review for the success criterion of the KBPMM in PMS. The percentages were calculate based on the scale that being rated by the expert.

Table- II: percentages of the satisfaction and acceptance.

Criterion	Description	% of the acceptance
Efficiency	Is the suggestion provided by the system can help the administrator in improving the performance?	73.33 %
Functionality and Correctness /accuracy	Is the system flow process same with the proposed model? The system has all the function and capabilities the same with the proposed model	70.00 %
Usefulness	Is the system helpful in controlling and improving university performance?	80.00 %
Ease to use	Is the system easy to understand?	66.67 %
Understandable	The information provided by the system is clear	66.67 %

From the conclusion of the results and reviews from the experts, they agreed that the model is suitable for being applied in the university's strategic plans as one of the alternatives to improve the performance. However, in some contrast, they suggested that the model should be open to international performance analysis and the model need to be embedded into Artificial Intelligence (AI) dashboard so that the model can be more independent. As this model is more focused on staff contributions, they also advised that the system should be tested by the real users who directly involved in managing and controlling the institution's performance so that the model can handle more than one perspective (staff contributions) in the future. The expert also advised to improve the current developed model. In Table- III shows the summary of the suggestions provided by the expert.

Table- III: Summary of the suggestions from the experts

Summary of the suggestions from the experts
1. The model should aim to focus more in-depth on another aspect. The focus aspect not only focuses on one perspective, which is staffs but will also take into account for budget and another constraint.
2. Improve the implementation of the system to become more in AI as the system have a simulation process to display the result.
3. Use the huge amount for data sample to identify the data trend so that the system able to predict the result more accurate.
4. Test the effectiveness of the model to more institutions and compare the progress result.

There are some limitations while conducting this research. The constraints and limitation of this research are as in Table- IV;

Table- IV: Constraints and limitations of the research

Constraints and limitations
1. Due to the scope of the research, other aspect other than staff's contributions are not considered.
2. The criteria in MyRA is always changing year by year, so past data are not really relevant to be used in the current year.
3. The case study of the research is using only one institution. As such, comparison of the PMM among different institution cannot be done. This is due to the confidentiality of data involved in the PMM.

VII. CONCLUSION AND FUTURE WORK

Designing a model that capable in measuring the actual performance is aimed at helping the HEI's administrator to measure the performance of the institution in all aspects. Besides, this model gives the impact for HEI in planning the strategic plan in the future and also helps in

monitoring the current performance of the institutions. In addition, all the process in this model is focused on finding the most suitable solution for improving institution performance. In the next stage, this model expected able to be a simulation system that makes it much easier for the administrator to handle and control the performance

cooperation in evaluating this research model and system.

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