Towards Designing Tools for Universities' R&D Performance Measurement on Mobile Platform

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Abstract—At the moment, there is a great interest in most universities to achieve higher ranking for better international standings and visibility. With shrinking resources such as financial and infrastructures, there is also a huge demand for the university to move forward and perform better in Research and Development (R&D) in each evaluation year. Key Performance Indicator (KPI) is an excellent tool to enculturate research in a Higher Education Institution (HEI). The culture must be built upon HEI's strength and weaknesses. Hence, the right decision making tool must be develop to priorities different agendas such as QSWUR, THE, etc. Mobile platform provide an efficient way to engage with stakeholders particularly to measure HEI performance on R&D. There are three main activities involves for developing a decision support tool for measuring R&D impact in HEIs i.e. development of decision model using multi criteria decision making, dashboard prototype development including and UI/UX for mobile platform. This paper describe the importance of measuring the impact of R&D, prioritization technique and the process of prototype development. It is anticipates that our work could mitigate the gaps and improve the research ecosystem in HEIs.

Keywords—Higher Education Institution, Key Performance Indicator, Multi Criteria Decision Making Problem (MCDM)

1 Introduction

The term "World-class university" or "global ranking" has become a phrase of buzzword to measure the quality of learning and research in tertiary education internationally. Moreover, it is importantto develop the capacity to compete in the global tertiary education marketplace through the acquisition and creation of advanced knowledge(Salmi, 2015). Apparently, the obsession to be a world-class university or to the global ranking has attracted large attention from higher education institution and governments. Thus, the workload of academic staff is increasing to cater the university needs. Salmi (2015) summarized three important complementary sets of factors that could be found among top universities:

- A high concentration of talent (faculty and students)
- Abundant resources to offer a rich learning environment and conduct advanced research
- Favourable governance features that encourage strategic vision, innovation and flexibility, and enable institutions to make decisions and manage resources without being encumbered by bureaucracy

KPI is an important tool to create a culture for R&D. KPI can be regarded as a numeric or categories measures which are used to describe the operating performance of an organizational or individual. KPI measures the domain range from long term properties to short terms measurements. In theory, the selection processes of KPI is based on quantitative and qualitative criteria and will be used for decision making to justify resources allocation in the institution. However, in reality, with the increasing demand for the HEIs to fulfil the national and international standing, policy makers in university tend to design KPIs based on their intuition without addressing the conflicting criteria, availability of resources/constraints and the diverse talent of academicians in HEIs. Hence, policymaker must prioritize the important agendas to fulfil the HEI's goals. There are five factors that suggested by several authors in their articles to considered for KPI selection i.e. KPI should be flexible, realistic, easy to achieve and easy to modify. There are two basic types of KPI selection which are numeric and non-numeric (Asaka, Aila, Odera, & Abongo, 2010).

2 Literature Review

2.1 Measuring research and development in higher education institutions

In the university's ecosystem, R&D focuses more on research and development activities that include basic scientific research conducted in universities as well as in collaboration with outsiders such as other universities, external and industrial agencies. R&D at universities will involve research teams from various academic disciplines aimed on producing scientific studies that will eventually produce new products, ideas or new work processes or improvements.

These results can be innovated by having networks within and outside the university and resulting in university performance excellence with the involvement of various parties and disciplines. In an effort to encourage researchers and creating innovative environment, the university needs to give freedom by promoting scientific achievements, ensuring that every R&D is promoted either within or outside the university and indirectly enhances university research performance excellence.

This also helps to improve the performance of researchers inside and outside the university. Research in universities will not only enhance the dignity and performance of a university system, but will also become an important asset to the nation (Kamaruzaman, 2016). The outcome of research will be resulted in the form of quantity or quality of publication, innovation or knowledge transfer. Table 1 shows the factors influencing the selection of KPIs for R&D activities in HEIs.

According to Majda& Alice (2016); Jiang (2014); Purnus&Bodea (2014), factors that can be considered are realistic and decision-oriented. This indicates that each KPI should be logical, practical and reasonable. Each KPI must be measurable, achievable and realistic to ensure R&D excellence (Majda& Alice 2016; Jiang 2014; Shahin&Mahbod 2007; Bititci, Mendibil, Martinez, & Albores 2005). Each KPI should be more focused and easy-to-reach (Kaganski, Karjust, &Majak, 2016). Based on Jiang (2014); Shahin&Mahbod (2007), KPI shoule be designed related to skills and knowledge to ensuresustainable R&D performance. This aspect will help policymakers to plan and strategies (Ribeiro, 2015).

According to Jiang (2014); Shahin&Mahbod (2007), the time-frame factor is expected to all project members that need to follow in order to facilitate performance assessed and measured. More systematic time-frame factor will help policymakers make more effective and relevant decisions based on established KPIs (Vachnadze, 2016).

Table 1. InfluencingFactors for Selecting Key Performance Indicators for HEIs Research and Development (R&D)

Authors/Factors	Realistic	Achievable	Readiness	Measurable	Timeframe
Bittici (2005)	√	√			
Y.Jiang (2015)	√	√		√	√
Shahin&Mahbob (2006)	√	√	√	√	√
Majda& Alice (2016)	√	√			
Purnus&Bodea (2014)			√		
Ribeiro (2015)	√		√		
Kaganski,Karjust, & Majak (2016)		√			
Vachnadze (2016)					√

Shahin&Mahbod (2007) emphasized that KPI provides a preliminary view of the organization's performance excellence. Jiang (2014) and Shahin&Mahbod (2007) asserts that a large organization will have a KPI list that illustrates the various standards and targets to be achieved. However, the management is still faced with dilemma to define the KPIs that should be prioritized and focus on the objectives of the R&D program at HEIs (Majda& Alice, 2016). On the other hand, Majda& Alice, (2016), states that too many or fewer KPIs will affect the performance of HEIs.Prioritization of KPI's should be taken seriously by policy makersto minimize the risks associated with setting goals for HEIs. In the previous study, Majda& Alice, (2016); Kaganski, Karjust, &Majak, (2016); Jiang, (2014);

Shahin & Mahbod, (2007) states quantitative methods are applied to resolve on priority issues within the KPI allocation. It will help the university achieve excellence in performance for R&D projects. This performance excellence will impact the university ratings locally and internationally. Decision making processes based on qualitative and quantitative criteria have been used for decision making in various

application (Rahman, Sobri, Omar, Benjamin, & Ramli, 2014; Nursal, Omar &Nawi, 2015; Goh, Goh, Omar, Toh, &Zin, 2016). Decision making process is based on the previous and current performance. The selection process is necessary to ensure that KPIs are fairly distributed and to avoid waste the resources. Moreover, it will minimize potential misalignment as there is a gap between strategic planning and strategy implementation.

2.2   Prioritization using Analytical Hierarchy Process

A number of quantitative techniques were introduced by previous researchers forMCDM. Among the most popular are Analytical Hierarchy Process (AHP), SMARTER and Fuzzy AHP. KPI prioritization is important to rank which agenda is important in order to design a more robust and fair KPI system. According toIslam & Mohamed (2018); Wan Mustafa, Mohd Shokury, & Kamis (2016), AHP method is applied to rank the elements at every level except at the first level and from all ranks (P, for i=1,2 ….., n), the priority value of every pair wise can be acquired using the following mathematical rules:

If $P_i = P_j$, hence $a_{ij} = 1$

If $P_i < P_j$, hence $a_{ij} = (P_j - P_i) + 1$ and $a_{ji} = {}^1/a_{ij}$

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Step-by-step formula for determining the weight of the criteria (Wan Mustafa, Mohd Shokury, & Kamis, 2016):

- Sum of entries, a_{ij} of every column,

$$\begin{bmatrix} a_{11} & a_{2n} & \cdots & a_{1n} \\ a & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \\ \sum_{i-1}^{n} a_{i1} & \sum_{i-1}^{n} a_{i2} & \cdots & \sum_{i-1}^{n} a_{nn} \end{bmatrix}$$

- Devide each entry in *j* column of matrix *A* with the sum of entries in *j* column. The resulting matrix is referred to a normalized pair wise comparison matrix.

$$N = \begin{bmatrix} w_1 & w_1 & \cdots & w_1 \\ w_2 & w_2 & \cdots & w_2 \\ \vdots & \vdots & \ddots & \vdots \\ w_n & w_n & \cdots & w_n \end{bmatrix}$$

- Compute the weights by dividing every additional entry in *I* row with *n* size of matrix *A*, the sum of the value of weights is equal to 1, $\sum_{i-1}^{n} w_i = 1$

$$\overline{w} = \begin{bmatrix} \dfrac{w_i + w_1 + \cdots w_1}{w_2 + w_2 + \cdots w_2} \\ n \\ \vdots \\ \dfrac{w_n + w_n + \cdots w_n}{n} \end{bmatrix}$$

The procedure for computing the consistency of a pair wise comparison matrix is as follows:

- Multiply matrix A with weight, *w, Aw*

$$AW = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix}$$

- Compute n_{maks}

$$n_{\text{maks}} = \frac{1}{n} \sum_{i-1}^{n} \frac{\text{entry} - \text{i in Aw}}{entry - iinw}$$

- Compute the consistency index, *IK*

$$IK = \frac{n_{maks} - n}{n - 1}$$

- Compute the random index, *IR*

$$IR = \frac{1.98\,(n - 2)}{n}$$

- Compute the consistency ratio, *NK* by comparing the index, *IK* with the random index, for appropriate n.

$$NK = \frac{IK}{NR}$$

The scale of priority value of pair wise comparison matrix is 1-9, hence the differences in rank of more than 9 (10 and above), thus, priority value must assume 9.

2.3 Advanced modelling for KPI design and implementation

After the output yield from the previous stage, we will develop a linear utility function to compute overall score of KPI for each faculty. In addition, we will profile and cluster based on faculty's competency or talents. KPI target will be automatically calculated based on the predicted and actual data. The modelling using AHP, clustering and linear function will be used on the next phase of the study i.e. mobile based KPI dashboard.

2.4 Mobile Based Kpi's Dashboard Design

Visualizing on KPI's data to measure R&D performance is important to yield a broader impact towards stakeholders in HEIs. It can provide valuable insights for academic staffs and administrators to strategies and improve research ecosystem in the institution. The dashboard prototype can be extended to other platform such as mobile for better engagement and personalized with stakeholders.

Our future works will consist of decision model development based on decision modelling with MCDM, dashboard prototype development and UI/UX activities for mobile application (Figure 1). This will consist stakeholder's involvement in our project and milestone will be set. Specific agendas such as QSWUR, THE, Malaysian Research Assesment (MyRA), etc. will also be prioritised based on the importance to the university growth and development.

3 Discussion And Conclusion

R&D activities are often linked to organizations that actively engage with research and development activities, collaborate with other entities such as entrepreneurs to produce new or improved product or work processes. Sustainable R&D ecosystem is the result of effective planning from strategic to operational level. KPIs creates an important role to nurture the R&D culture in an institution.It is an important tool in managing and measuring the performance of an organization. It links between organizational objectives and strategies with all activities to achievebetter performances (Ballard, 2013). The tool does not only measures and collects different data and information, but it is also provide a benchmark for management to determine the planning and execution that needs to be done based on existing information. Organizational KPI performance depends on an efficiency of benchmarking metric.

KPIs will guide the organization to achieve excellence in performance. The stakeholders should take into account the capabilities of each organizational unit to prevent imbalances (Jiang, 2014). Jiang (2014) also express theimbalance of distribution or equality between performance benchmarking and strategic planning metrics. Each KPI has a weight that will be affect the achievements (Carlucci, 2010). Jiang (2014); Asaka, Aila, Odera, &Abongo (2010); Bititci, Shahin&Mahbod (2007) and Mendib, Martinez, &Albores (2005) also emphasize that the weight allocation should be given serious attention by stakeholdersby setting their priorities and importance in influencing performance achievement or goals.

Efficient decision making tool will assist policymakers in decision making to determine which KPIs should take precedence in the implementation of the strategy. In this paper, we demonstrates the importance of a fair and efficient KPI system. Our future works will consist of modelling using MCDM, clustering with data mining, development of KPI utility function, Dashboard prototype with UI/UX for mobile application.
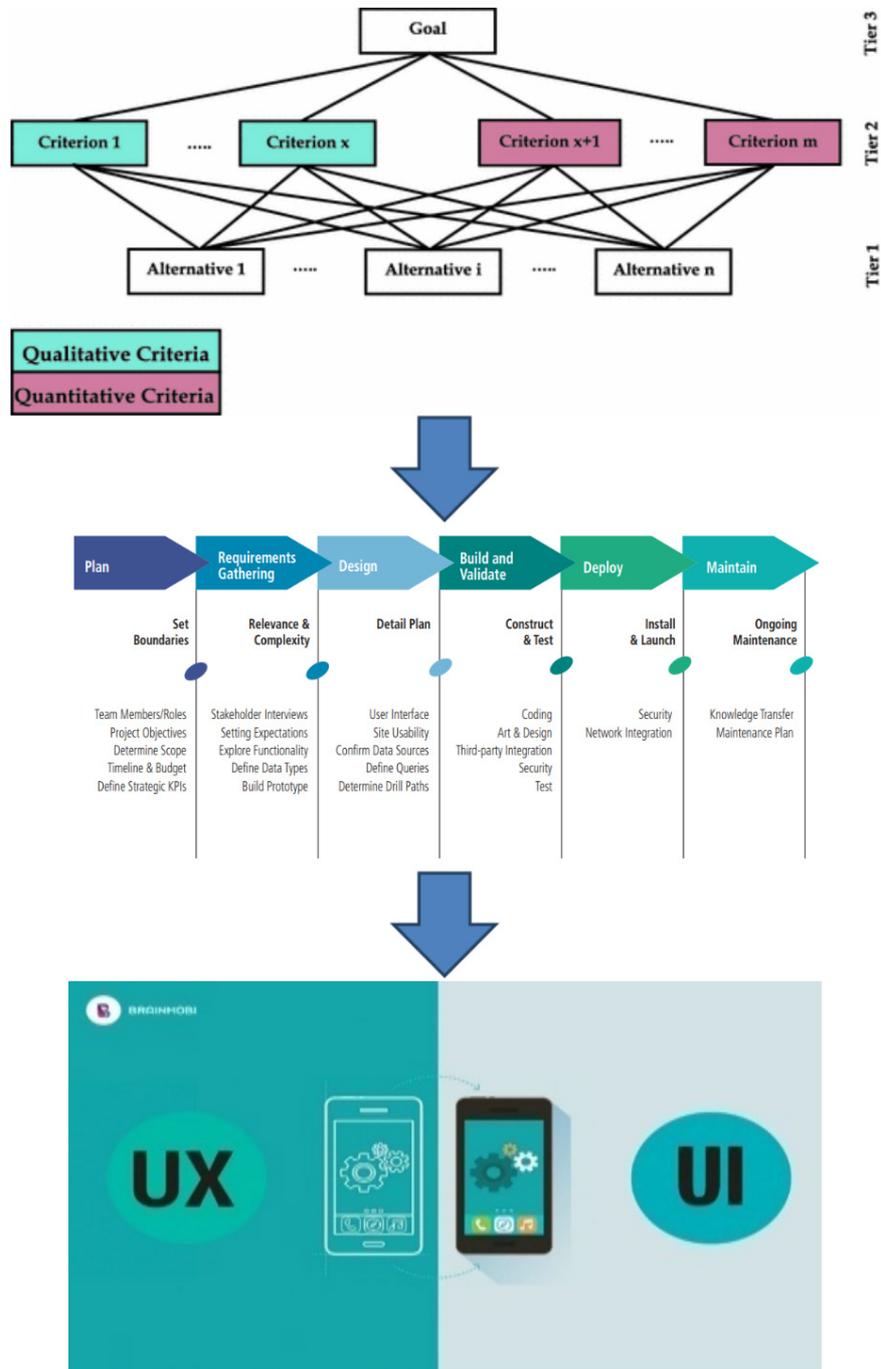
Fig. 1. .Mobile based KPI's Dashboard for Measuring Performance(Neotix Corporation, 2008;
Bhattacharjee, Bepari, &Bhaumik, 2014;Shashankmehrotra, 2019)

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