

DEVELOPMENT OF SUSTAINABLE KEY PERFORMANCE INDICATOR (KPI) MONITORING AND CONTROL SYSTEM USING VIABLE SYSTEM MODEL

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Abstract—Key Performance Indicator (KPI) delivery process is needed in the measurement of staff improvement and productivity in all types of organization as a feedback process. If the KPI delivery process is disrupted or destroyed, then generally the strategic goals of an organization are likely to fail. Organization such as the Institution of Higher Learning (IHL) contains hundreds of staff at different levels, categories and designations. In the IHL, scholarly publication is one of the key performance index set by the management to their academic staffs. All academic staffs of an IHL are involved in the KPI delivery process within their organization in order to ensure staff achieve their KPI targets. However, with different levels, categories and designations of academic staffs, the management encounters difficulties in delivering and monitoring staffs' achievement and performance. This paper discusses the use of Viable System Model as diagnostic tool to analyze the KPI Delivery Process of scholarly publication by academic staffs in the Institution of Higher Learning. Using this model, the organizational analysis was done by selecting one IHL as case study and separated it into meta-system and sub-system during the analysis. The results of the diagnostic were then used to develop a sustainable framework for the development of Sustainable Key Performance Indicator Monitoring and Control System. The main capability highlighted by this system is sustainable feedback features. The use of the ICT based system for monitoring and controlling the KPI delivery process is aim at ensuring the academic staff achieves their target KPI set by their management and support their organization's mission, vision and strategic goals.

Keywords- Key Performance Index, Organizational Analysis, Viable System Model, Monitoring and Control System, KPI Delivery Process

I. INTRODUCTION

Monitoring and control of Key Performance Indicators (KPIs) in organizations provide real-time information about the activity status of the delivery process as well as

performance evaluation. By having this capability, organizations can figure, track and analyze desired KPIs and take actions. It is important to monitor and control such KPIs in order to overcome the dangers associated with their disruption or termination. Since KPIs are used as feedback mechanisms, institutions of higher learning (IHL) has adopted their usage as a form performance measurement to enhance productivity among academic staff.

II. RELATED WORKS

Diagnosing performance processes has been an active area of research over the last few decades. Most noticeable is the work of [1], where VSM was used to diagnose the sustainability of biosocial interaction in a society. According to Espinosa and Walker, VSM provides the template that can be used to map the complexity of society thereby providing the best method to achieve sustainable societal processes. But their work is a broad context looking at the society as a whole. A major weakness of their approach is the difficulty in the implementation and it does not cover the cultural, political and technological aspect relevant to sustainability. Another important contribution is by [4], he utilizes VSM at community level to foster adaptation to sustainability. Leonardo [4], uses the VSM framework by exploring three levels of recursion; the household, the neighborhood and the city, and this approach was more looking at the political as well as cultural changes that may affect sustainability. But also this work do not cover the technological aspect. In their work, [3] uses VSM as a proof of concept to identify the influential components in organizations that needs immediate intervention. This work of [3] has also not looked at the technological point of view. It is important to note that all the literatures presented used VSM as a template as well as diagnosis tool to identify the gap in their context.

The two works that are similar to our work are those of [2] and [5]. In [2], they applied the concept of VSM in information system planning and modeling but they are looking more to the structural relationship of the units in the organization. Also it looks at the integrity of the structure and the deployment of information across the organization.

Our work differ slightly in these works by introducing the sustainability concept to the organizational processes. That is how the KPI delivery process can be made sustainable in the dynamic world. And this can be achieved by integrating other methods with VSM.

Many researchers [16], [17], [18], [19] and [20], uses VSM with other models by pointing to the limitation of VSM as an abstract model that can be expandable with other models. However, in our work, we looked at VSM as a strong model that can stands on its own but only adding some initial strategies that can help in the VSM diagnosis.

III. PROPOSED METHOD

In this study, we propose a five-step activity model in developing a sustainable key performance indicator (KPI) monitoring and control system. This model is similar to [5] and steps involved are; Identification of organizational KPIs; Organizational analysis; quantitative and qualitative analysis; VSM analysis; and, Information system tool as shown in Figure 1. The following paragraphs explains the five-step model which we would test using one of the public universities in Malaysia.

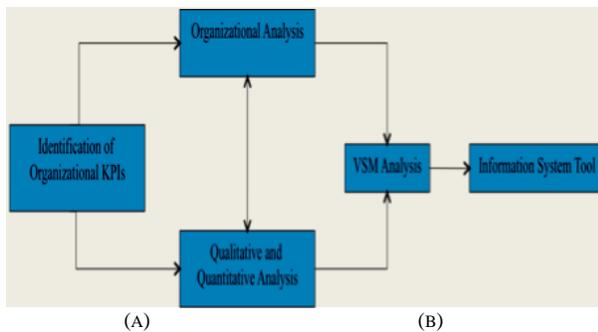


FIGURE 1. FIVE-STEP MODEL OF DEVELOPING KPI MONITORING AND CONTROL SYSTEM

Our new model/framework will be composed of four phases (Figure 2) and each of these phases have a beginning and an end with some overlapping, this means there is some VSM activity, data collection and feedback during the entry phase, some entry, VSM activity and feedback during data collection, some entry, data collection and feedback during VSM activity and some entry, data collection and VSM activity during feedback. The proposed framework is displayed in Figure 2, and the following paragraphs explain the components of the proposed framework.

A. Identification of Organizational KPIs

Most IHL now operate based of strategic goals being set in order to achieve their targets. Therefore the identity of each organization is based on the KPIs available to improve the organizational status. In [5], this stage deals with the identification of the system under investigation. For the development of a sustainable KPI monitoring and control

system, one has to decide which of the organizational KPI will be put under consideration [15]. This will help in narrowing the scope and importance of the system to be developed.

B. Organizational Analysis

In this step, an in-dept document analysis is done on the organization and the selected KPI of the organization. This phase is similar to [Espejo et al, 1999] and [Briones-Juarez, 2010] where organizational data was examined to bring out issues of relevance to a VSM analysis. Also in Hoverstadt (2011), this stage unfold the complexity of the fractal structure of operations and delivery process in the organization. Therefore the researcher may require a study the available resources from the organizational websites and intranet. Also from news papers and observation will help in having a clear understanding of the organizational operations.

C. Qualitative and Quantitative Analysis

This can be called the primary data collection stage, where selected respondents will be surveyed based on the available data from organizational analysis and their role in achieving the selected KPI of the organization. [6] has similarly used qualitative and quantitative instruments in identification of operational elements within an organization. Also [7] has used qualitative approach to forecast patterns and levels of offending and to optimize various police, judicial and prison processes using Viable System Model. In this step, several approaches can be employed based on the number of respondents available.

D. VSM Analysis

The results from the organizational analysis and quantitative and qualitative analysis will be used in VSM analysis [11] and [12]. The organizational stakeholders would be represented in a recursive structure. The recursive nature of VSM will enable the researcher to identify the unsustainable factors that affect the KPI delivery and also suggests a sustainable tool that will help in achieving the targets based on monitoring and control of the KPI. The concept of using VSM as an analysis tool follows the work of [8] and [9].

E. Information System Tool

This is the final step of the proposed model, it is the development phase of the monitoring and control system that was suggested in the VSM analysis. This phase is similar to that of [9], where the information system tool developed reflects the user requirement from the VSM analysis, this attempts to make the tool a sustainable one. It will be also in this stage that an evaluation test is undertaken

on the developed system in order to assess its usefulness to the users in the organization [13].

IV. CASE STUDY OF UNIVERSITI TEKNOLOGI MALAYSIA

In this work, we used an institution of higher learning to demonstrate the effectiveness of our proposed model. Universiti Teknologi Malaysia, a leading research university in Malaysia was chosen as our case study. And the institution is currently working hard to maintain its research status in which one of the determining factor is the output on academic staff publications. For two consecutive years (2009, 2010) the university has not meet the target set on the academic staff on these publications. Therefore, the situation has become as problematic as well as unsustainable that requires diagnosis in order to identify areas and corrective action to be taken. This research aims at diagnosing the current situation has made the following hypothesis in Table 1.

TABLE 1. RESEARCH HYPOTHESIS

H1:	That the management encounters difficulties in delivering and monitoring staffs' achievement and performance due to poor information system tool in place
H2:	That if there is resistance from the academic staff to use the new system, then it will affect the number of publication output.

The reason for our hypothesis is that, the current system similar to giving the monitoring and control function is electronic appraisal system (EAS) in place. The following paragraphs explain the overall organizational diagnosis using the proposed framework.

A. Identification of Organizational KPIs

The internal process strategic objective of Universiti Teknologi Malaysia has Scholarly Publication & Citation as one of the major KPIs with the following as the elements of that KPI: Cummulative impact factor of publications; Non citation index papers=2.67 paper per staff = 2947; Book chapters=1.13x1104 staf=1248; No. of original books authored (karya asli). From the record it has been shown that the KPI on scholarly publications and citations from 2008 to 2010 has not been achieved (Table 2).

Table 2: Set and achieved UTM KPI targets

KPI Name	2008		2009		2010	
	Expected Target	Achieved	Expected Target	Achieved	Expected Target	Achieved
Scholarly Publication	Not available	< 300	1000	321.46	3000	513

B. Organizational Analysis

In this analysis, we divided the stakeholders of KPI delivery process of scholarly publications and citations into a pyramid (Figure 2) that shows the levels of delivery and the task of each stakeholder in each stage of the process. The lower level comprises of what we call the “information provision”, [15] which involves the academic staff and the research groups as a whole. This level is responsible for the publication aspect and they are the operational elements. Therefore whatever this level generates will be passed to the next level of the pyramid, which involves those, responsible for the “collection and reporting” of the data. In this level the research alliances and the research support unit of the library (RSU-PSZ) are responsible for this process. The collection and reporting involve the use of information technology, for example, currently they use applications such as Excel and emails to collect and report the publication data to the next level of the pyramid. In the next upper level of the pyramid is the office of the deputy vice chancellor on research and innovation (TNCPI) which is responsible for “monitoring” the overall processes undertaken by the stakeholders in the lower levels of the pyramid. The TNCPI is answerable to the management of the institution that makes the final “decisions”.



Figure 2: Pyramid of KPI delivery

The current academic staff of UTM as at 15 March 2011 were 2320, of these number, 346 (14.9%) are from the K-Economy Research Alliance, which consists of group of interrelated research units. The Knowledge-based economy (K-economy) research alliance is an organ of the Research Management Center (RMC) of UTM. The research alliance has a sizable number of research groups and all research groups are made up of academic staffs as members. These members are drawn from eight faculties forming 35 Research Groups. Of the 35 Research Groups, the faculty of computer science and information systems (FSKSM) has 6 K-Economy research groups with a total of 89 members forming 25.72% of the K-Economy Research Alliance. These Academic staff are categorized into two, the (A):

70% Research & 30% Teaching (B): 30% Research & 70% Teaching. Each category also belongs to a research group (RG). This categorization is to enable the staff to be more focused on a particular area for the delivery of their KPIs.

C. Qualitative and Quantitative Analysis

The target population for the study comprised 346 members of the K-Economy Research Alliance of UTM. Out of the sample frame of 346 members of K-Economy Research Alliance (RAKE) in UTM, a sample size of eighty-nine (89) respondents were selected based on faculty of the respondents, which we considered Faculty of Computer Science and Information Systems (FSKSM). Out of the 89 questionnaires that were administered, 51 questionnaires constituting of 57.3 percent response rate were collected. An analysis of item reliability was computed using the scale analysis of SPSS. The Cronbach alpha coefficient shows that the questionnaire items have relatively high internal consistency of 0.912. And according to George and Mallery (2003), that items that have a higher degree of reliability are those that achieve a score of 0.8 or higher in the reliability statistics.

- Demographic Factors:

Majority of the respondents are between the ages of 31 to 40, showing that they are young. Which according to the interviews made by the researcher shows that old age goes with higher productivity due to experience and exposure. Majority of the respondents are married (96.1 percent), in which family issues can also influence productivity. Majority of the respondents have worked in the institution for more than 10 years. Therefore change in culture may affect their productivity as reported by Davidson (2006).

This section presents an overview of some of the analyzed results. We consider two issues among the highlighted issues from the interviews and the questionnaire;

- The need for an enhanced annual evaluation and appraisal system (ELPPT):

The respondents from the academic staff were worried with the annual evaluation and appraisal system (ELPPT) although it is new. The system inability to link their publications already submitted when a request is made for them to resubmit. An important observation from the respondents' comments was that the ELPPT is opened only once a year, and does not show their progress to determine their work in progress.

- Factors associated with the EAS:

On the issue of time consuming, two questions were posed to the respondents and in the first one which we are presenting; that says the current EAS is not linked to any

database to retrieve my data automatically. 51% agree, 7.8% disagree while 39.2% were uncertain and 2% have no response. Therefore we conclude that the EAS is time consuming, as staff reportedly complains on the data entry aspect of the system instead of automatically retrieving their documents from existing databases. The EAS do not have effective and satisfactory feedback mechanism is another question that 58.8% agree, 7.8% disagree, 16% were uncertain and 2% no response. This clearly shows why there is so much resistance to the use of the EAS.

- Constraints that influence academic staff productivity

Unrealistic targets were also measured, and from the respondents, 52.9% agree that the targets are not realistic, while 17.6% disagree and 29.4% were uncertain.

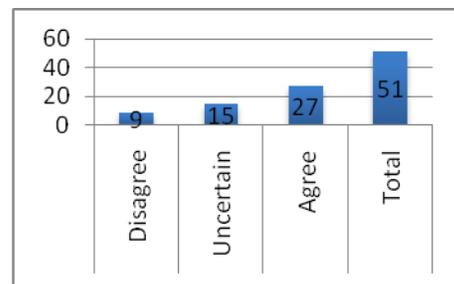


Figure 3. Unrealistic targets

D. VSM Analysis

In this phase, we have applied the concept of recursion [8] to the entire KPI delivery process, and the outcome results to four recursion levels (Figure 4). Each recursion level describes the activities of that part of the process. Each recursive level must be thought of as a Viable Unit in its own right; i.e., the means to maintain an identity if separated from the whole recursive scheme is inherent in the organization (recursive level) itself. Briefly, in discussion with respondents, it was found that the situation was complex and non-deterministic.

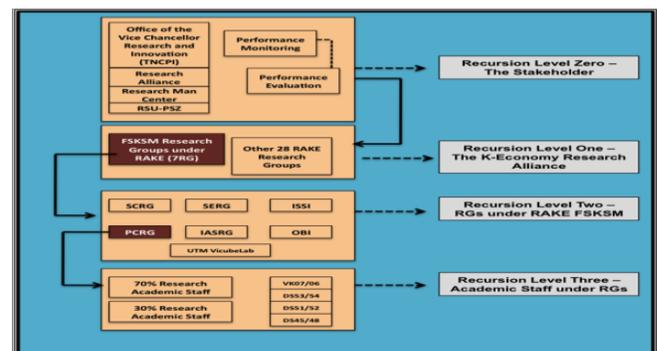


Figure 4: Identified recursion levels

Recursion level 0 is Stakeholder, which constitutes the major players in the KPI delivery process on scholarly publications and citations. This recursion level forms the “whole” which have other levels of recursions, for example all the research alliances form another recursion level that also have its own VSM subsystems. This went further to another recursion level such as the research groups, and these are derived from the upper level of recursion (research alliance). At the 1st recursion level (recursion level three), there are the academic staff, which handles all the information provision or data generation on scholarly publications and citations. These group is categorized into (A): 70% Research & 30% Teaching (B): 30% Research & 70% Teaching. Each category also belongs to a research group (RG), and also have different cadre of appointment from VK07: Professor down to DS54: academic staff with PhD.

At recursion level 0, there are 2 System 1 Divisions at this recursive level: research alliances, Research Support Unit of Library. The *agreed purpose* relating to these divisions is as follows:

To provide and monitor the KPI delivery of scholarly publications and citations from academic staff, ensuring that all sources of publication data from other sources such as Web of Science and Scopus and others are collected and confirmed, and to continually report the outcome in order to help on maintaining the research university status.

E. Information System Development

This section discusses the process of developing a prototype KPI Delivery monitoring and control tool based on the features and requirements that have been collected through the sets of data collection techniques that were given by and discussed with the stakeholders as well as the VSM analysis. The design represents the structure of the system-to-be as perceived by the user. The system design is developed for the purpose of providing functionality, or behavior that will satisfy the user expectations and then develop a prototype system. Also in this section, a user acceptance test was conducted and presented. The system was developed using PHP 5.2 as the scripting language and MySQL Community Server 5.0 as the databases management system.

Figure 5, show the login page of the proposed system, this allows the user to enter the username and password in order to get access to the system, this interface also gives a welcome message to the user especially guest user. After having access to the system the user will be presented will list of options to select from.

The usability of this system is categorized into three; one for those responsible in data collection and reporting, which will use the system functionality to upload all the data they get from different sources, and the system will

automatically picked the only required fields and also remove duplications if any and arrange them according to the university’s standards. Figure 6, is the page where the data is being uploaded. And Figure 7 shows the summary table of the data in the database. Also Figure 8 shows the detail KPI delivery status of an academic staff.



FIGURE 5: SYSTEM LOGIN PAGE



FIGURE 6: DATA IMPORT PAGE

The second users of this system would be the management and the academic staff themselves, which will require to know the current status of the scholarly publications and citation acquired by the stakeholders. Therefore from the menu presented to the user, one can select to know the status of a particular academic staff, a particular research group or a particular research alliance.

Quick Import and Reporting System	
Item Recorded	
Index	
Title:	Efficiency and economics of different herbicides in aerobic rice system
Author(s):	Jaya Suria A.S.M., Jumini A.S., Rahman M.M., Miao A.B., Selamat A.
UTM's Author(s):	Selamat A.
Staff No.:	2345 Scopus:7 WOS:1
Journal Title:	African Journal of Biotechnology
Volume:	10
Issue:	41
Page/Ination:	8007-8022
Year of Pub:	2011
Impact Factor:	0.43
Faculty:	FRSM
Journal Status:	Scopus
REF:	SIANG
REF PSZ:	PS23A
<input type="button" value="Submit"/> <input type="button" value="Reset"/> <input type="button" value="Upload FULLTEXT"/>	
(c) UTM Copyright 2011	

FIGURE 7: PUBLICATION RECORD

Academic Staff KPI Progress Report				Year 2010
Staff Name	Prof. Sri Marwan Shamsudeen		Staff Category	70% Research
Staff RG	SCRC	Staff RA	RAKE	(Total Number of Citations)
Expected Target Value (CEP)	1.50	Achieved Target Value (CEP)	1.417	
Expected Target Value (NCEP)	2	Achieved Target Value (NCEP)	2	
Number of Papers in Scopus	2	Status	<input type="button" value="OK"/> <input type="button" value="Detail"/>	
Number of Papers in Web of Science	2			
<input type="button" value="Print Report"/> <input type="button" value="Contact Staff"/>				
		Warning		
		Critical		

FIGURE 8: DETAIL ACADEMIC STAFF RECORD

V. EVALUATION OF THE TOOL

Acceptance test was conducted to introduce the new system to staff members in-charge of collecting and reporting KPI targets on Scholarly Publications and Citations in RSU-PSZ and RAKE. Because the actual users

of this system are not many, only two in RSU PSZ and only three in RAKE, this assessment included three respondents from the total users. After the introduction part, the SPC-QIR was introduced by demonstrating the capabilities and functions of the new system system. Among the 3 respondents, all are females. The position of the respondents is research and administrative officers. All the staff in-charge of the KPI collection and reporting has a wide range of working experience. Two of the respondents, have 10 years and above of working experience. One of them, has 2 to 4 years of working experience. The instrument consists of 6 background information items, 4 items on the perceived usefulness, and the perceived ease of use and 2 questions on the features of the new system. This questionnaire used a five-point likert scale. The reliability of this instrument has a Cronbachs Alpha value of 0.955. Before the evaluation started, the researcher explained to the respondents all the features available, what are the functions of each feature, and how it will contributes to help KPI delivery of Scholarly Publications and Citations. In question about the benefit of this system to the UTM research community (Figure 10), the total percent of agree and strongly agree were 100%.

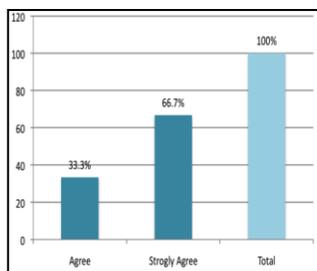


FIGURE 9: IMPORTANCE OF THE SYSTEM

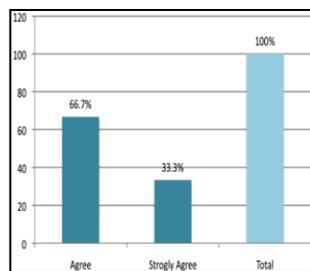


FIGURE 10: USEFUL FEATURES

The result of question about if the system has useful features that provides immediate and updated information on Scholarly Publication was 100% agree (Figure 11). However, 66.7% of the respondents were neutral about the screen elements such as buttons and menu options, (Figure 12) which shows the need of improvement on the user friendly aspect of the system. On whether the respondents feel that this system can be recommended to the UTM management for immediate use, 100% have agreed to that (Figure 13).

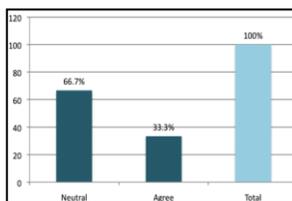


FIGURE 11: SCREEN ELEMENTS CLARITY

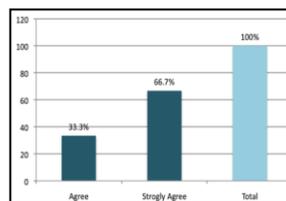


Figure 12: Recommended the System

VI. CONCLUSION

Monitoring and control of KPI delivery process with effective feedback mechanism was the major contribution of this work, where the various data coming from different sources are being managed together and presented to the user such as the management of the institution. We believe that this study, together with the prototype system developed will aid in quick decision making as well as improved KPI delivery process. The use of VSM in this study has shown that system thinking approach can be the best method to tackle a complex situation such as the KPI delivery process that involves various stakeholders with different needs and complexity. Although, only one KPI was considered in this study, we believe it will provide the foundation for the development of sustainable key performance indicator (KPI) monitoring and control system using viable system model

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