Timeliness, Steadiness, Behaviourness and Effortlessness: An Efficiency Evaluation Model for Measuring Mobile Applications Usage

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Abstract—**Both the theory and practice of measuring the efficiency of mobile applications usage have been hampered by the absence of a thorough mathematically based model as a method for evaluation. This research effort has been in a position to derive a preliminary mathematically based specification and measurement scheme specifically for assessing the mobile applications usage from the perspective of efficiency measures. The ultimate value for developing a mathematical oriented approach is to provide a systematic and quantitative method for conducting mobile applications usage efficiency evaluation research. As a result, a total number of 39 metrics and 10 attributes and 4 criterions were identified having associated towards measuring the efficiency of mobile applications usage. The applicability of the model was also tested on two experimental systems: Training Evaluation System (PELAKAD) group where participants manipulated the cadet training tasks; and Clinical Information System (CAPSULE) group where participants manipulated the clinical delivery tasks). Analysis of the efficiency on both types of systems was assessed in terms of timeliness, steadiness, behaviourness, and effortlessness. As a result, it was concluded that the model developed and proposed in this study provides a common basis for comparison between systems as well as helping in selecting suitable product based on their needs and requirements. By producing a quantifiable measurement, the overall efficiency of mobile applications usage thus can be assessed.**

Index Terms—**Efficiency Measure; Evaluation Framework; User Interface; Mobile Applications.**

I. Introduction

Nowadays, mobile devices are finding their way into anyone, anytime, anywhere and anything computing environments [1]. This is due to the devices significant advantages provided to its users, in terms of affordability, portability, accessibility and functionality [2]. The variety of capabilities of these devices have led to tremendous expansion of mobile applications being designed and developed over the past few years [3]. Thus, challenged the design and development of mobile applications towards superior quality, an important one is being efficient, in order to compete in the market place [4]. However, due to the hardware and software constraints (i.e. small screen size, data entry problems, connectivity issues, and varying display resolutions), there are many aspects to consider for designing and developing efficient mobile applications [5]. Such aspect that need to be taken into account is a number of evaluation procedures for assessing and measuring the efficiency of mobile applications among its respective users [6].

Overall, the study of the phenomena in the field of evaluating mobile applications is highly driven by quality perspective and concentrates primarily on producing useful and usable products rather than reflecting on measuring the usage effectiveness in detail. For examples, quality models developed, described efficiency as the key factor in the development of successful mobile-based software applications [7]. Other researchers continued the study with the development of software certification framework and models for evaluating mobile applications efficiency [8]. Meanwhile, Fadzlah et al. proposed the concept of efficiency in assessing the usability of mobile applications usage [9]. Yet, only a few viewed as independent models which lay down general measures and measurements to demonstrate the evaluation of mobile applications efficiency. Most of them focused on evaluating the efficiency of very specific types and usages of mobile applications [10].

There are many ways in which evaluations can be described [11]. One of the current trends in evaluating mobile applications is using a mathematical modelling approach [12]. Mathematical modelling approach is the art of translating problems from an application area into tractable mathematical formulations whose theoretical and numerical analysis provides insight, answers, and guidance useful for the originating application [13]. There are several works done on evaluating mobile applications using a mathematical modelling approach [14]. However, none of the researchers concentrated on developing a mathematical model for assessing and measuring mobile applications efficiency, in general. Due to this reason, the strong demand for developing a new evaluation method for measuring mobile applications efficiency via mathematical modelling approach thus burgeoning.

II. Theoretical Background

Efficiency may refer to a measure of doing things in the most economical way (good input to output ratio) and the state of being efficient and competency in performance. Efficiency in a general term is an accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort. Both definitions were supported by many researchers that relates efficiency as a measure of usage effort and timeliness with which the specified goals or sub-goals of using particular system can be achieved. Usage effort generally defines as the quality of requiring or showing little strength or power, whether physical or mental, in performing an act or aiming at an object. Such effort is achieved only after hours of practice which shows more or less strenuous endeavor, struggle, force acting directed to the accomplishment of an object.

Meanwhile, timeliness is subject to occurring at a suitable or opportune time, acting at a fitting or advantageous time or performed exactly at the time appointed. Timeliness also refers to the amount of elapsed time, length of time or expectation time takes to obtain specific action, information that is specifically assigned.

Other researchers mentioned efficiency reflected by the emotional conditions and stability of usage in order to achieve certain goals. Emotional conditions focused on the behavior of the users while dealing with the targeted goals. User behavior thus can be referred to the degree of actions or reactions of an object or human in relation to stimuli such as the specific task, equipment and environment. Particularly, behaviorness is an anthropomorphic construct that assigns to define the acceptability of the activities that humans can interact with. Meanwhile, stability of usage can be measured by the quality of being steady or securely and immovably fixed in place as stable in position, movement or action. The term also used as steadiness to urge someone to be under control, stable, regularly or continuously that denotes free from change, variation or interruption of actions done.

III. EFFICIENCY FRAMEWORK

In this paper, a new evaluation method for measuring the efficiency of mobile applications was proposed, focusing on measuring the mobile applications usage with mathematical modelling approach. This research considers specifically the measurements of efficiency parameters useful to express and estimate the overall efficiency of mobile applications usage. As a result, a new and simple mathematical-based evaluation model for measuring the efficiency of mobile applications, namely Efficiency Evaluation Model (EEM), was established.

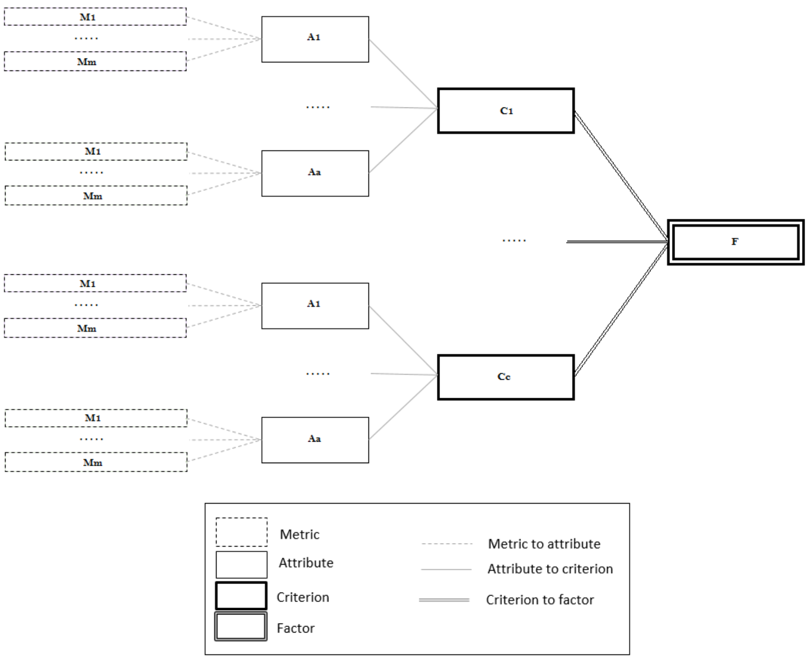

Figure 1: Efficiency evaluation framework

This model extended the hierarchical conceptual and empirical relationship-driven framework developed by Fadzlah [15] that brings together different measures in different hierarchy levels. Each level represents interaction with other level and impacts one another to measure the desired mobile applications usage with which explained as either none, one or more metrics could represent a single attribute. The combination of these metrics could be represented as the measures that contributed to only one attribute. Further, the combination of these attributes could be represented as the measures that contributed to only one criterion. Finally, these criterions are used to support in the calculation of the factor that can be concluded as directly affected the final measure of mobile applications usage, efficiency. This is the case at every level in which could be represented as an M-1 relationship. For example, metric $M_1 \ldots M_n$ are the input to attribute A_1 and criterion C_1 is an output for the attribute A_1. Consider if the value of metric M_1, M_2, … , M_{n-1} or M_n increases so as the value of attribute A_1 and criterion C_1. Again, if the value of metric M_1, M_2, … , M_{n-1} or M_n decreases so as the value of attribute A_1 and criterion C_1. Figure 1 shows the framework consisted of criterions, attributes and metrics for measuring mobile applications efficiency.

A. Materials and Methods

The main purpose of this study was to develop a model describing a mathematical-based evaluation technique for assessing the efficiency of mobile applications. As a result, a total number of 39 metrics and 10 attributes and 4 criterions were identified having associated towards measuring the efficiency of mobile applications usage. The metrics of each efficiency measure as well as the classification of these metrics according to its corresponding hierarchy levels is as shown in Table 1 below.

Table 1
Efficiency measures and categorization

Factor	Efficiency									
Criterion	Timeliness				Steadiness		Behaviourness		Effortlessness	
Attribute	Until Event	Interaction Mode	Learning Interval	User Speed	Optimal Solution	Lateral Position	Emotional Expression	Physiological Reaction	Working Memory	Interface Complexity
Time to begin task	●									
Time in performing task	●									
Time in pausing task	●									
Time to finish	●									
Time to successfully complete task	●									
Time of targets pointed		●								
Time of action presented		●								
Time of data retrieval		●								
Time to successfully complete interaction		●								
Time of knowledge acquired			●							
Time of understanding gained			●							
Time of rememberability obtained			●							
Time to successfully complete learning			●							
Rate of tasks completed				●						
Rate of error corrected				●						
Rate of characters entered				●						
Rate of pages scrolled				●						
Distance of slips occurred					●					
Distance of mistakes made					●					
Angle of screens viewed						●				
Angle of texts showed						●				
Angle of graphics displayed						●				
Frequency of facial expressions changed							●			
Frequency of vocal cues indicated							●			
Frequency of eye movements traced							●			
Frequency of postural conditions observed							●			
Change of skin conductance detected								●		
Change of blood pressures showed								●		
Change of pupillary responses								●		
Change of brain waves								●		
Change of heart beat recorded								●		
Change of body heat								●		
Frequency of decision made									●	
Frequency of problem solved									●	
Frequency of comprehension gained									●	
Frequency of contexts satisfied										●
Frequency of contents handled										●
Frequency of layouts preferred										●
Frequency of controls used										●

B. Measurement Items

The iterative development of scales was designed based upon a number of 39 proposed metrics for measuring the efficiency of mobile application. These metrics (measured and expressed in units) were collected and gathered by considering multiple theories to integrate both objective and subjective measures for efficiency evaluation. The original metrics were modified to address the requirements for assessing the importance of measuring the efficiency of mobile application usage and specific user tasks. For example, to modify the efficiency metric into question, 'frequency of postural conditions observed'. Thus result, 'I think, it is important to measure the user's frequency of postural conditions changed within session or treatment' question. This scales consisted of 39 items rated on a five-point Likert scale from extremely agree, slightly agree, neutral, slightly disagree and extremely disagree.

C. Analysis of Responses

A total number of 397 targeted participants responded. After exclusion of duplicate entries and missing entries (more than 3.27% of incomplete data), there were 384 valid responses. This study used list wise deletion for missing and duplicate data, therefore only valid responses were used. The perceived mobile usage competency of the respondents was high. Results reported more than 50% of respondents somewhat agreeing, strongly agreeing and extremely agreeing that they were competent.

IV. MODEL CONSTRUCTION

In order to develop a mathematical model in assessing the efficiency of using handheld applications, this study was designed to follow five main procedures: extraction of weightage values, representation of values into codes, optimization of parameters, construction of mathematical equations and development of evaluation model.

A. Weightage Extraction

Weightage extraction was performed based on previous work regarding the identification and determination of measures for assessing the efficiency of mobile applications. The scale was used to gather information from respective users to indicate their level of agreement towards the importance of each efficiency measure, based on their experience and perception. Data collected were entered into the statistical software program for analysis. Relationship evaluation test was carried out in the software program to determine the strength between measures in different hierarchical levels to obtain the weightage values. The weightage value for each metric, attribute and criterion for measuring the efficiency of mobile applications is shown in Table 2.

B. Code Specificity

Formula for calculating the efficiency of mobile applications could also be constructed by applying weights. Weight values were coded either as w_{ATTm} for representing weight value of metric, or w_{CRTa} for representing weight value of attribute or w_{EFFc} for representing weight value of criterion. The generic symbol w_{ATTm} represents the weight code of metric mth that contributes towards its corresponding attribute $_{ATT}$. Meanwhile, symbol w_{CRTa} represents the weight code of attribute ath that contributes towards its corresponding criterion $_{CRT}$. Finally, symbol w_{EFYc} represents the weight code of criterion cth that contributes towards measuring the overall efficiency of mobile applications, $_{EFY}$. The code specificity for each metric, attribute and criterion for measuring the efficiency of mobile applications is shown in Table 2 below.

C. Optimization of Parameter

Lists of codes were produced to represent each efficiency metric, attribute and criterion, presented as $M_m \bullet A_a \bullet C_c \bullet F_{EFF}$, $A_a \bullet C_c \bullet F_{EFF}$, and $C_c \bullet F_{EFF}$, respectively. M represents metric, meanwhile A represents attribute, and C represents criterion, whereas F represents efficiency as a factor for assessing mobile applications. Based on the rank order for each metric towards its corresponding attribute, presented as $M_m \bullet A_a \bullet C_c \bullet F_{EFF}$, $_m$ represents the sequential series (m-th) of the metric, such as 1, 2, …, m, that contributed towards a particular attribute, $_a$. In addition, presented as $A_a \bullet C_c \bullet F_{EFF}$, $_a$ represents the sequential series (a-th) of the attribute, such as 1, 2, …, a, that contributed towards particular criterion, $_c$. Finally, presented as $C_c \bullet F_{EFF}$, $_c$ represents the sequential series (c-th) of the criterion, such as 1, 2, …, c, that contributed towards efficiency as the factor for assessing the mobile applications, in which $_{EFY}$ represents the abbreviation of Efficiency. The linearity code for each metric, attribute and criterion for measuring the efficiency of mobile applications is shown in Table 2 below.

D. Mathematical Equation

An equation of efficiency metric was formulated to determine the relative quantification of a target activity in comparison to a reference activity. The efficiency metric expression ratio ($M_m \bullet A_a \bullet C_c \bullet F_{EFY}$) of a target activity is calculated based on the value of activities performed E_{target}, where the deviation is the difference between an actual activity and an expected activity, $\Delta_{target\ (actual - expected)}$. This was expressed in comparison to a reference activity calculated based on the total number of activities performed $E_{\text{reference}}$, calculated based on the par value of the expected activities $\mathrm{T}_{reference\ (expected)}$.

Equation 1 shows a mathematical model of relative expression ratio in quantifying efficiency metrics. The ratio is expressed as minus 1 of the value of the actual versus expected (with or without par value) target activity in comparison to a reference expected activity, E_{target} is the observed efficiency metric of target activity transcript, $E_{\text{reference}}$ is the observed efficiency metric of reference activity transcript, $^{\Delta\ target}$ is the deviation of actual – expected of the target activity transcript, and $^{\mathrm{T}\ reference}$ is the total of expected reference activity transcript. The expected activity could be a constant and a regulated transcript, which means that for the calculation of efficiency metric ratio ($M_m \bullet A_a \bullet C_c \bullet F_{EFY}$), the individual target expected activity, $^{target\ (expected)}$ and the reference expected activity, $^{reference\ (expected)}$ of the investigated transcript must be known, and only dependent on the target actual activity $^{target\ (actual)}$.

$$= 1 - \left[\frac{(E_{\text{target}})^{\Delta\ target\ (actual - expected)}}{(E_{\text{reference}})^{\mathrm{T}\ reference\ (expected)}} \right] \quad (1)$$

Table 2
Weightage value, weightage code and linearity code

Measures	Linearity Code	Weightage Code	Weightage Value
Efficiency	F_{EFY}	-	-
Timeliness	$C_1 \bullet F_{EFY}$	w_{EFY1}	.446
Until Event	$A_1 \bullet C_1 \bullet F_{EFY}$	w_{TML1}	.401
Time to begin task	$M_1 \bullet A_1 \bullet C_1 \bullet F_{EFY}$	w_{UE1}	.444
Time in performing task	$M_2 \bullet A_1 \bullet C_1 \bullet F_{EFY}$	w_{UE2}	.674
Time in pausing task	$M_3 \bullet A_1 \bullet C_1 \bullet F_{EFY}$	w_{UE3}	.501
Time to finish	$M_4 \bullet A_1 \bullet C_1 \bullet F_{EFY}$	w_{UE4}	.400
Time to successfully complete task	$M_5 \bullet A_1 \bullet C_1 \bullet F_{EFY}$	w_{UE5}	.631
Interaction Mode	$A_2 \bullet C_1 \bullet F_{EFY}$	w_{TML2}	.504
Time of targets pointed	$M_1 \bullet A_2 \bullet C_1 \bullet F_{EFY}$	w_{IM1}	.364
Time of action presented	$M_2 \bullet A_2 \bullet C_1 \bullet F_{EFY}$	w_{IM2}	.286
Time of data retrieval	$M_3 \bullet A_2 \bullet C_1 \bullet F_{EFY}$	w_{IM3}	.414
Time to successfully complete interaction	$M_4 \bullet A_2 \bullet C_1 \bullet F_{EFY}$	w_{IM4}	.561
Learning Interval	$A_3 \bullet C_1 \bullet F_{EFY}$	w_{TML3}	.396
Time of knowledge acquired	$M_1 \bullet A_3 \bullet C_1 \bullet F_{EFY}$	w_{LI1}	.505
Time of understanding gained	$M_2 \bullet A_3 \bullet C_1 \bullet F_{EFY}$	w_{LI2}	.480

Time of rememberability obtained	$M_3 \bullet A_3 \bullet C_1 \bullet F_{EFY}$	w_{LI3}	.504
Time to successfully complete learning	$M_4 \bullet A_3 \bullet C_1 \bullet F_{EFY}$	w_{LI4}	.545
Steadiness	$C_2 \bullet F_{EFY}$	w_{EFY2}	.450
User Speed	$A_1 \bullet C_2 \bullet F_{EFY}$	w_{STD1}	.602
Rate of tasks completed	$M_1 \bullet A_1 \bullet C_2 \bullet F_{EFY}$	w_{US1}	.553
Rate of error corrected	$M_2 \bullet A_1 \bullet C_2 \bullet F_{EFY}$	w_{US2}	.579
Rate of characters entered	$M_3 \bullet A_1 \bullet C_2 \bullet F_{EFY}$	w_{US3}	.485
Rate of pages scrolled	$M_4 \bullet A_1 \bullet C_2 \bullet F_{EFY}$	w_{US4}	.364
Optimal Solution	$A_2 \bullet C_2 \bullet F_{EFY}$	w_{STD2}	.236
Distance of slips occurred	$M_1 \bullet A_2 \bullet C_2 \bullet F_{EFY}$	w_{OS1}	.490
Distance of mistakes made	$M_2 \bullet A_2 \bullet C_2 \bullet F_{EFY}$	w_{OS2}	.425
Lateral Position	$A_3 \bullet C_2 \bullet F_{EFY}$	w_{STD3}	.474
Angle of screens viewed	$M_1 \bullet A_3 \bullet C_2 \bullet F_{EFY}$	w_{LP1}	.451
Angle of texts showed	$M_2 \bullet A_3 \bullet C_2 \bullet F_{EFY}$	w_{LP2}	.537
Angle of graphics displayed	$M_3 \bullet A_3 \bullet C_2 \bullet F_{EFY}$	w_{LP3}	.538
Behaviourness	$C_3 \bullet F_{EFY}$	w_{EFY3}	.444
Emotional Expression	$A_1 \bullet C_3 \bullet F_{EFY}$	w_{BHV1}	.664
Frequency of vocal cues indicated	$M_1 \bullet A_1 \bullet C_3 \bullet F_{EFY}$	w_{EE1}	.546
Frequency of facial expressions changed	$M_2 \bullet A_1 \bullet C_3 \bullet F_{EFY}$	w_{EE2}	.526
Frequency of eye movements traced	$M_3 \bullet A_1 \bullet C_3 \bullet F_{EFY}$	w_{EE3}	.458
Frequency of postural conditions observed	$M_4 \bullet A_1 \bullet C_3 \bullet F_{EFY}$	w_{EE4}	.532
Physiological Reaction	$A_2 \bullet C_3 \bullet F_{EFY}$	w_{BHV2}	.434
Change of skin conductance detected	$M_1 \bullet A_2 \bullet C_3 \bullet F_{EFY}$	w_{PR1}	.214
Change of blood pressures showed	$M_2 \bullet A_2 \bullet C_3 \bullet F_{EFY}$	w_{PR2}	.355
Change of pupillary responses	$M_3 \bullet A_2 \bullet C_3 \bullet F_{EFY}$	w_{PR3}	.243
Change of brain waves	$M_4 \bullet A_2 \bullet C_3 \bullet F_{EFY}$	w_{PR4}	.611
Change of heart beat recorded	$M_5 \bullet A_2 \bullet C_3 \bullet F_{EFY}$	w_{PR5}	.556
Change of body heat	$M_6 \bullet A_2 \bullet C_3 \bullet F_{EFY}$	w_{PR6}	.454
Effortlessness	$C_4 \bullet F_{EFY}$	w_{EFY4}	.568
Cognitive Workload	$A_1 \bullet C_4 \bullet F_{EFY}$	w_{EFL1}	.533
Frequency of decision made	$M_1 \bullet A_1 \bullet C_4 \bullet F_{EFY}$	w_{CW1}	.532
Frequency of problem solved	$M_2 \bullet A_1 \bullet C_4 \bullet F_{EFY}$	w_{CW2}	.600
Frequency of comprehension gained	$M_3 \bullet A_1 \bullet C_4 \bullet F_{EFY}$	w_{CW3}	.441
Interface Complexity	$A_2 \bullet C_4 \bullet F_{EFY}$	w_{EFL2}	.465
Frequency of contexts satisfied	$M_1 \bullet A_2 \bullet C_4 \bullet F_{EFY}$	w_{IC1}	.498
Frequency of contents handled	$M_2 \bullet A_2 \bullet C_4 \bullet F_{EFY}$	w_{IC2}	.522
Frequency of layouts preferred	$M_3 \bullet A_2 \bullet C_4 \bullet F_{EFY}$	w_{IC3}	.476
Frequency of controls used	$M_4 \bullet A_2 \bullet C_4 \bullet F_{EFY}$	w_{IC4}	.433

An equation for assessing efficiency attributes of mobile applications was formulated by determining the relative summation of the product of weight and value in comparison to the average of weight. In detail, the attribute expression ratio ($A_a \bullet C_c \bullet F_{EFY}$) of mobile applications efficiency is calculated based on the total product of each metric weightage (w_{ATTm}) multiplied by the corresponding metric values ($M_m \bullet A_a \bullet C_c \bullet F_{EFY}$), and expressed in comparison to the average weightage of metric (w_{ATTm}). Equation 2 shows a mathematical model of relative expression ratio in quantifying efficiency attributes of mobile applications.

$$= \left[\frac{\sum_{m=1}^{m} w_{ATTm} \left(M_m \bullet A_a \bullet C_c \bullet F_{EFF} \right)}{\left[\sum_{m=1}^{m} w_{ATTm} \right]} \right] \quad (2)$$

Meanwhile, an equation for assessing efficiency criterion of mobile applications was formulated by determining the relative summation of the product of weight and value in comparison to the average of weight. In detail, the criterion expression ratio ($C_c \bullet F_{EFY}$) of mobile applications efficiency is calculated based on the total product of each attribute weightage (w_{ATTa}) multiplied by the corresponding attribute values ($A_a \bullet C_c \bullet F_{EFY}$), and expressed in comparison to the average weightage of attribute (w_{ATTa}). Equation 3 shows a mathematical model of relative expression ratio in quantifying efficiency criterions of mobile applications.

$$= \left[\frac{\sum_{a=1}^{a} w_{ATTa} \left(A_a \bullet C_c \bullet F_{EFF} \right)}{\left[\sum_{a=1}^{a} w_{ATTa} \right]} \right] \quad (3)$$

Finally, an equation for assessing the total amount of mobile applications efficiency (F_{EFY}), was formulated based on the total product of each criterion weightage (w_{ATTc}) multiplied by the corresponding criterion values ($C_c \bullet F_{EFY}$), and expressed in comparison to the average weightage of criterion (w_{ATTc}). Equation 4 shows a mathematical model of relative expression ratio in quantifying efficiency of mobile applications.

$$= \left[\frac{\sum_{c=1}^{c} w_{ATTc} \left(C_c \bullet F_{EFF} \right)}{\left[\sum_{c=1}^{c} w_{ATTc} \right]} \right] \quad (4)$$

E. *Efficiency Evaluation Model*

As a result of these quantification methods, a model, namely Efficiency Evaluation Model (EEM), has been proposed which suggests how mobile applications efficiency should be evaluated. The model is organized by metrics, attributes, criterions and efficiency as the factor for assessing mobile applications. For each attribute, the model describes relevant efficiency metrics appropriate for measurement and potential evaluation measures. The classification scheme in Figure 2 summarizes the construct and the measures proposed throughout this research, and advanced the efficiency evaluation by providing a quantitative approach in assessing the general efficiency of mobile applications.

The existence of interrelations between metrics and attributes should be taken into account in determining the level of efficiency of mobile applications. Due to the linear and hierarchical structure of the EEM, any changes to metrics will result in changes to the attributes and consequently on the overall efficiency of the mobile applications usage. For example, a low score on the matric (i.e., time to successfully complete learning ($M_4 \bullet A_3 \bullet C_1 \bullet F_{EFY}$) will directly affect the score of the attribute Learning Interval ($A_3 \bullet C_1 \bullet F_{EFY}$), criterion of Timeliness ($C_1 \bullet F_{EFY}$) and finally results in significant implications for the overall efficiency (F_{EFY}) of mobile applications usage, and vice versa).

However, to obtain the precise numeric value is as tangible as the likelihood of occurrences is impossible. Fortunately, exact figures for measuring efficiency are not needed since the numbers are mostly used for comparison purpose only. Thus, prioritizing the efficiency can be done by converting the values into words or sentences with which the evaluator from various background and understanding can interpret the information accurately and comprehensively. Prioritizing overall efficiency usage can be categorized into five distinct classifications (refer Table 3). The lowest level indicates the most badly absence or shortage of a desirable usage efficiency whilst the highest level represents outstanding or fulfilment of a desirable usage efficiency with high distinction of proficiency. It is important to note that prioritizing the level for measuring the efficiency of mobile applications usage mentioned above is flexible and does not fixed to the stated figures. The scores for each level are open for customization and tailored to specific requirements according to the maturity of the mobile applications itself or based on the evaluator's wishes.

Table 3
Prioritizing overall efficiency score

Score	Level	Status	Description
$F_{EFF} < 0.200$	1	Worst	Most badly absence or shortage of a desirable usage efficiency that results users unable to perform comprehensively
$F_{EFF} < 0.400$	2	Inadequate	Lack of a desirable usage efficiency that results users with the least excellent to perform task
$F_{EFF} < 0.600$	3	Acceptable	Average of a desirable usage efficiency that can be tolerable to be considered as good enough
$F_{EFF} < 0.800$	4	Excellent	Complete the specific requirements of a desirable usage efficiency that achieves almost in a state of being practical
$F_{EFF} \leq 1.000$	5	Outstanding	Fulfilment of all requirements of desirable usage efficiency that achieves very high distinction of proficiency

V. EXPERIMENTAL DESIGN

All participants were selected from a system design class and randomly distributed in two experimental groups: Training Evaluation System (PELAKAD) group where participants manipulated the cadet training tasks; and Clinical Information System (CAPSULE) group where participants manipulated the clinical delivery tasks). The PELAKAD group performed the experiment first and followed by the CAPSULE group. Both groups followed the same procedure: between-subjects experimental design with two conditions (participants either worked only on the evaluation task or reporting task). Participants were categorized based on their expertise in using mobile devices (i.e., advanced, expert, intermediate or novice). Order of participation was fully counterbalanced and participants were randomly assigned to conditions.

A 5.5” 720 x 1280 display pixels with Super AMOLED capacitive touchscreen mobile device with 16 GB (11 GB user available) of 2 GB RAM and Android OS v4.3 (Jelly Bean) was used for the experiments. A personal computer with Microsoft Windows XP operating system connected to an 18” LCD monitor with 1280x 1024 resolution was also used as supporting tool for the experiment. Experimenters were selected from a voluntary basis and each experimenter was randomly assign to only one participant. Participant actions towards completing tasks were also recorded using experimenter's smartphone build-in camera. Quantitative data for each participant were collected and reported in an open ended questionnaire survey. For example, “How long does the participant take to complete entering data on the evaluation form?”, “How many times does the participant use help function to complete tasks?” and etc. A user manual was also prepared on each of the experiment table to guide participants to successfully complete given tasks.

The procedures were designed to fit into a single 1-hour for each session and the experiment was conducted in a private computer laboratory while participants were attending classes. At the beginning of the day, the experimenter explained the purpose of the study and participants were given a mobile device with an Android platform and the participants would work with the systems. Participants were first given an open ended survey question to measure their prior knowledge on assessing mobile applications efficiency. Then, participants were asked to complete their task before completing a background questionnaire to collect their demographic information as well as the information about their mobile usages (i.e., expertise, frequency of usage, duration of usage and etc.). Finally, self-reported subjective data was collected using 7-point Likert scales on overall efficiency.

Eleven efficiency measures were recorded for each of the evaluation and reporting tasks in both experimental groups of PELAKAD and CAPSULE. Three measurable items involved with measuring the timeliness (i.e., time to successfully complete task, time to successfully complete interaction, time to successfully complete learning), three measurable items involved with measuring the steadiness (i.e., rate of tasks completed, distance of mistakes made, and angle of screens viewed), three measurable items involved with measuring user behavior (i.e., frequency of vocal cues indicated, frequency of facial expressions changed and frequency of postural conditions observed), and two measurable items involved with measuring user effort (i.e., frequency of problems solved and frequency of controls used). The par value for each of the measured items were also determined and set to be not more than 30% out of each of the total measured items.

A. Study 1: PELAKAD System

Training Evaluation System, which is known by the acronym PELAKAD, was developed to facilitate the main two tasks of entering cadet training evaluation scores and delivering the training evaluation report, especially on marching by officers of the Military Training Academy (ALK) in the parade. There are four objectives in the development of PELAKAD system, 1) to design a portable system that is based on the Android platform, 2) to implement the dogtag verification system using optical character recognition method, 3) to build an evaluation system using multimedia technology support, and 4) to develop evaluation report delivery system using built-in sharing application.

Tasks. Participants on the evaluation tasks, were firstly asked to launch the PELAKAD system by clicking on the icon displayed on the main page. A main page of a list of evaluated cadets were displayed and participants needed to find the add icon to create new evaluation data. Next, participants were assigned to scan a given dogtag until it successfully displayed the particular number and the photo of the new cadet. Once the participants had correctly scanned the dogtag, the start recording button was displayed and participants were directed to record a video of a pre-recorded marching cadet on an 18” LCD monitor with 1280x1024 resolution. Participants were then completed entering the scores of five evaluation criteria and finally selected the calculate button to obtain the overall scores and achievement level of the particular cadet. The system automatically saved the information and listed the newly created information on the PELAKAD main page. Participants were asked to repeat the cycles into five trials.

In reporting task, participants were asked to follow the step-by-step procedure given in a list of paper. Firstly, participants were directed to launch the PELAKAD system by clicking on the icon displayed on the main page. After a main page was displayed, participants needed to find and select a specific person from the main list to do a review process. The review page appeared on the screen and participants performed the review process by finding and clicking on the play button to watch the recorded video of a marching cadet. Evaluation scores and achievement level entered previously were checked and tallied with the given marks on the paper. After successfully completing the review process, participants were assigned to choose and select receiver for the report by clicking on the select receiver button. Participants were also asked to choose the built-in sharing applications for the delivery of the evaluation report and finally click the send button to confirm the delivery of the report to the receiver. The system automatically saved the information and listed the newly delivered information on the PELAKAD main page. Participants were asked to repeat the cycles into three trials.

Subjects. Overall, a sample of 22 subjects participated in the study (11 in the evaluation condition, and 11 in the reporting condition). Due to the nature of the particular domain scenario, only a few women participated (6 females; 4 in the evaluation condition and 2 in the reporting condition). The majority of participants were men with 7 males participated in the evaluation condition whereas 9 males in the reporting condition). Level of expertise between the two conditions were counterbalanced; with a number of 2 advanced mobile users, 7 expert mobile users, and 2 intermediate users were assign to the evaluation condition whereas 9 expert mobile users, 1 intermediate advanced user and 1 novice mobile user were assign to the reporting condition. All participants in the study were regular mobile users and had none experience working with the PELAKAD system.

B. Study 2: CAPSULE System

Clinical Information System (which is known by the acronym CAPSULE) was developed to facilitate the automated data entry and reporting of patient clinical information. There are four (4) objectives in the development of CAPSULE system, 1) to design a portable system that is based on the Android platform, 2) to implement the automated health system using ARM Cortex processing, 3) to build a reporting system with multimedia technology support, and 4) to develop report delivery system using built-in sharing application.

Tasks. Participants on the evaluation tasks, were firstly asked to launch the CAPSULE system by clicking on the icon displayed on the main page. A main page of a list of evaluated patients were displayed and participants needed to find the add icon to create new evaluation data. Next, participants were assigned to capture blood pressure with a given ARM device attached by the Bluetooth service until it successfully displayed the particular blood pressure readings of the new patient (in this case participants were asked to act as patients). Once the participants had correctly capture the blood pressure readings, the start recording button was displayed and participants were directed to record a video of a pre-recorded patient health problems on an 18” LCD monitor with 1280x1024 resolution. Participants were then completed entering the health problems and finally selected the analyze button to obtain the overall scores and health level of the particular patient. The system automatically saved the information and listed the newly created information on the CAPSULE main page. Participants were asked to repeat the cycles into five trials.

In reporting task, participants were asked to follow the step-by-step procedure given in a list of paper. Firstly, participants were directed to launch the CAPSULE system by clicking on the icon displayed on the main page. After a main page was displayed, participants needed to find and select a specific patient from the main list to do a review process. The review page appeared on the screen and participants performed the review process by finding and clicking on the play button to watch the recorded video of the selected patient. Evaluation scores and achievement level entered previously were checked and tallied with the given problems on the paper. After successfully completing the review process, participants were assigned to choose and select receiver for the report by clicking on the select receiver button. Participants were also asked to choose the built-in sharing applications for the delivery of the evaluation report and finally click the send button to confirm the delivery of the report to the receiver. The system automatically saved the information and listed the newly delivered information on the CAPSULE main page. Participants were asked to continue the cycles into three trials.

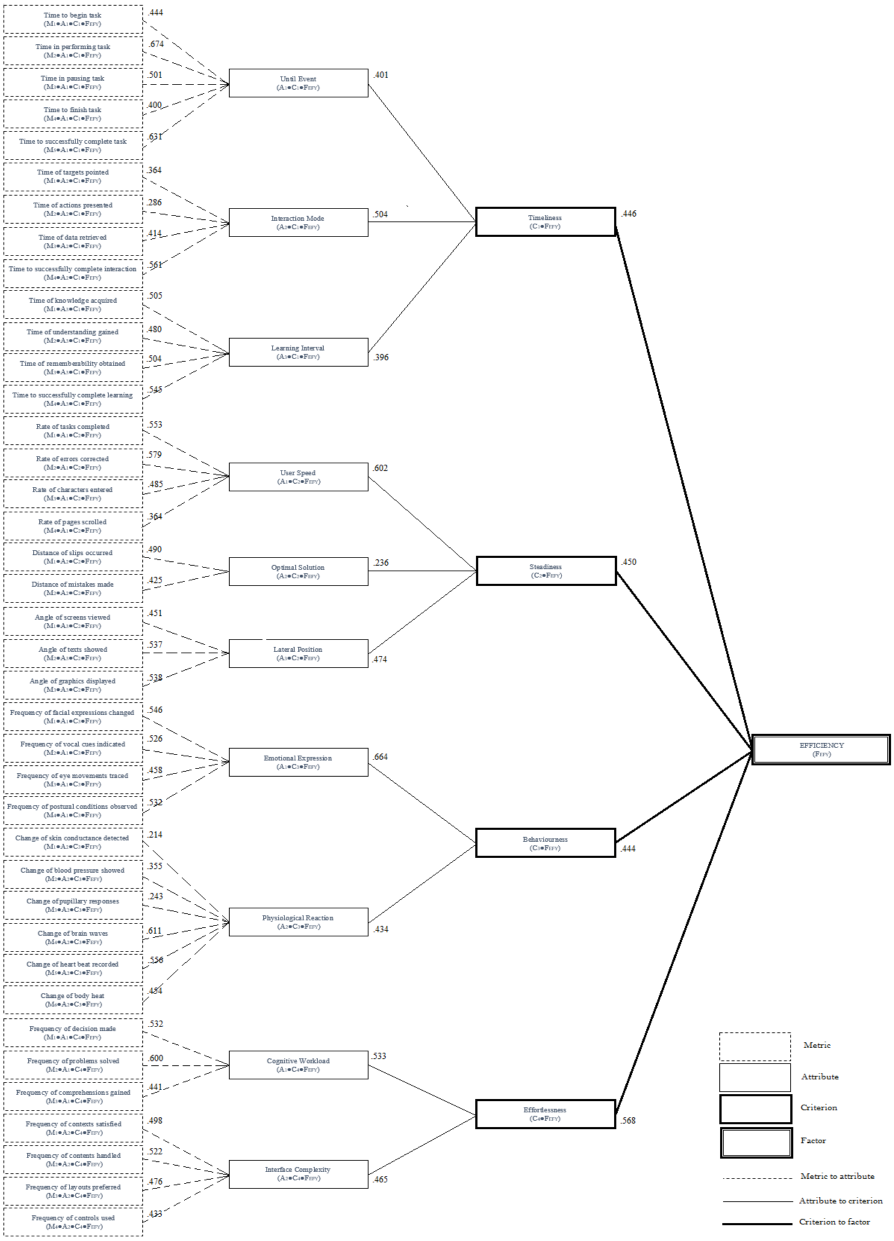

Figure 2: Efficiency Evaluation Model

Subjects. Overall, a sample of 11 subjects participated in the study (6 in the evaluation condition, and 5 in the reporting condition). Due to the nature of the particular domain scenario, only a few women participated (3 females; 2 in the evaluation condition and 1 in the reporting condition). The majority of participants were men with 4 males participated in the evaluation condition whereas other remaining 4 males in the reporting condition). Level of expertise between the two conditions were counterbalanced; with a number of 5 expert mobile users, and 1 intermediate user were assign to the evaluation condition whereas 1 advanced mobile user, 3 expert mobile users, and 1 intermediate advanced user were assign to the reporting condition. All participants in the study were regular mobile users and had none experience working with the CAPSULE system.

VI. Results And Findings

Table 4 shows the data collected for each experimental condition (PELAKAD group and CAPSULE group), comparing evaluation task and reporting task. Data were collected and categorized based on the four distinct efficiency measures of Timeliness (i.e., time to successfully complete task, time to successfully complete interaction, time to successfully complete learning), Steadiness (i.e., rate of tasks completed, distance of mistakes made, and angle of screens viewed), Behaviourness (i.e., frequency of vocal cues indicated, frequency of facial expressions changed and frequency of postural conditions observed), and Effortlessness (i.e., frequency of problems solved and frequency of controls used). Measurable items involved in this study were time (in seconds), rate (per task), distance (in millimeters), angle (in degree), frequency (of changes) and frequency (in numbers). In order to investigate the overall efficiency of the mobile applications usage, the average score of all participants involved in this study were computed. Final scores of metrics, attributes, criterion and overall efficiency for each experimental condition (PELAKAD group and CAPSULE group) working in the evaluation task is shown in Table 5.

Final results from the experiment showed that the score of metric time to successfully complete task, time to successfully complete interaction, angle of screens viewed, frequency of facial expressions changed, and frequency of postural conditions observed in evaluation task was slightly higher with PELAKAD experimental group if compared to participants dealing with CAPSULE system. As can be observed, the score of metric time to successfully complete learning, rate of tasks completed, distance of mistakes made, frequency of problems solved and frequency of controls used were slightly higher by participants working on CAPSULE system in the evaluation task if compared to PELAKAD group. However, no comparisons between groups can be made regarding metric of frequency of vocal cues indicated in the evaluation task since the scores for both experimental conditions were remain the same. The slightly higher scores of attribute Until Event, Interaction Mode, Lateral Position and Emotional Expression were also found in participants dealing with evaluation task on PELAKAD system. Timeliness and Behaviourness criterion scores were slightly lower in CAPSULE group working on evaluation task while Steadiness and Effortlessness were found slightly lesser in PELAKAD group. Finally, the overall efficiency scores were found higher in CAPSULE group working on evaluation task and thus showed that CAPSULE system were more efficient to be used for evaluation task if compared to the PELAKAD system.

Table 4
Collection of experimental data

Measure	Experimental Condition			
	Evaluation		Reporting	
	PELAKAD	CAPSULE	PELAKAD	CAPSULE
Timeliness measures				
reference time to successfully complete tasks	1500	1500	1500	1500
actual time to successfully complete tasks	1361	1468	1093	1228
expected time to successfully complete tasks	450[a]	450[a]	450[a]	450[a]
target time to successfully complete tasks	911[b]	1018[b]	643[b]	778[b]
reference time to successfully interact	900	900	900	900
actual time to successfully interact	882	896	784	629
expected time to successfully interact	270[a]	270[a]	270[a]	270[a]
target time to successfully interact	612[b]	626[b]	514[b]	359[b]
reference time to successfully learn	600	600	600	600
actual time to successfully learn	417	363	302	267
expected time to successfully learn	180[a]	180[a]	180[a]	180[a]
target time to successfully learn	237[b]	183[b]	122[b]	87[b]
Steadiness measures				
reference rate of tasks completed	75	75	75	75
actual rate of tasks completed	73	69	58	64
expected rate of tasks completed	22.5[a]	22.5[a]	22.5[a]	22.5[a]
target rate of tasks completed	50.5[b]	46.5[b]	35.5[b]	41.5[b]
reference distance of mistakes made	15	15	15	15
actual distance of mistakes made	8	5	9	6
expected distance of mistakes made	4.5[a]	4.5[a]	4.5[a]	4.5[a]
target distance of mistakes made	3.5[b]	0.5[b]	4.5[b]	1.5[b]
reference angle of screens viewed	25	25	25	25
actual angle of screens viewed	17	19	21	23
expected angle of screens viewed	7.5[a]	7.5[a]	7.5[a]	7.5[a]
target angle of screens viewed	9.5[b]	11.5[b]	13.5[b]	15.5[b]
Behaviourness measures				
reference frequency of vocal cues indicated	13	13	13	13
actual frequency of vocal cues indicated	7	7	6	5
expected frequency of vocal cues indicated	3.9[a]	3.9[a]	3.9[a]	3.9[a]
target frequency of vocal cues indicated	3.1[b]	3.1[b]	2.1[b]	1.1[b]
reference frequency of facial expressions changed	25	25	25	25
actual frequency of facial expressions changed	17	19	12	13
expected frequency of facial expressions changed	7.5[a]	7.5[a]	7.5[a]	7.5[a]
target frequency of facial expressions changed	9.5[b]	11.5[b]	4.5[b]	5.5[b]
reference frequency of postural conditions observed	25	25	25	25
actual frequency of postural conditions observed	17	21	19	22
expected frequency of postural conditions observed	7.5[a]	7.5[a]	7.5[a]	7.5[a]
target frequency of postural conditions observed	9.5[b]	13.5[b]	11.5[b]	14.5[b]
Effortlessness measures				
reference number of problems solved	12	12	12	12
actual number of problems solved	11	10	12	9
expected number of problems solved	3.6[a]	3.6[a]	3.6[a]	3.6[a]
target number of problems solved	7.4[b]	6.4[b]	7.4[b]	5.4[b]
reference number of controls used	35	35	35	35
actual number of controls used	27	21	23	31
expected number of controls used	10.5[a]	10.5[a]	10.5[a]	10.5[a]
target number of controls used	16.5[b]	10.5[b]	12.5[b]	20.5[b]

[a] 30% par value of expected activity, [b] scores of target activity (actual – expected)

Analysis of metric time to successfully complete task, rate of tasks completed, angle of screens viewed, frequency of facial expressions changed, frequency of postural conditions observed and frequency of controls used in reporting task were slightly higher with PELAKAD experimental group if compared to participants dealing with CAPSULE system. Results also found that the scores for each metric time to successfully complete interaction, time to successfully complete learning, distance of mistakes made, frequency of vocal cues indicated and frequency of problems solved were slightly higher for CAPSULE group completing the reporting tasks. Five attributes were found significantly higher to participants dealing with reporting tasks in PELAKAD group (i.e., Until Event, User Speed, Lateral Position, Emotional Expression and Interface Complexity) while the other four attributes were found significantly higher to participants dealing with reporting tasks in CAPSULE group (Interaction Mode, Learning Interval, Optimal Solution and Cognitive Workload). The analysis of the criterion Steadiness, Behaviourness and Effortlessness found that the score for performing reporting task while working with PELAKAD system was slightly higher than using CAPSULE system with the same task. Only one criterion (Timeliness) was found higher while using CAPSULE system to complete the reporting task. Therefore, results concluded that participants can be more efficient on reporting task while working with PELAKAD system.

The final scores indicate that both PELAKAD and CAPSULE systems used in the study indicated average of a desirable usage efficiency that can be tolerable to be considered as good enough for both the evaluation and reporting tasks. However, comparing to the experimental conditions thus confirmed that the efficiency of both PELAKAD and CAPSULE systems were significantly higher while working with reporting tasks than working with evaluation task.

VII. DISCUSSION AND CONCLUSIONS

Both the theory and practice of measuring the efficiency of mobile applications usage have been hampered by the absence of a thorough mathematically based model as a method for evaluation. As a result, this research effort has been in a position to derive a preliminary mathematically based specification and measurement scheme specifically for assessing the mobile applications usage from the perspective of efficiency measures. The ultimate value for developing a mathematical oriented approach is to provide a systematic and quantitative method for conducting mobile applications usage efficiency evaluation research.

Table 5
Overall efficiency evaluation score

Measures	Linearity Code	Experimental Condition: Evaluation – PELAKAD	Evaluation – CAPSULE	Reporting – PELAKAD	Reporting – CAPSULE
Efficiency	F_{EFY}	0.5108[a]	0.5366[a]	0.5834[a]	0.5782[a]
Timeliness	$C_1 \bullet F_{EFY}$	0.4292[b]	0.4285[b]	0.5847[b]	0.6415[b]
Until Event	$A_1 \bullet C_1 \bullet F_{EFY}$	0.3927[f]	0.3213[f]	0.5713[f]	0.4813[f]
Time to successfully complete task	$M_5 \bullet A_1 \bullet C_1 \bullet F_{EFY}$	0.3927	0.3213	0.5713	0.4813
Interaction Mode	$A_2 \bullet C_1 \bullet F_{EFY}$	0.3200[g]	0.3044[g]	0.4289[g]	0.6011[g]
Time to successfully interact	$M_4 \bullet A_2 \bullet C_1 \bullet F_{EFY}$	0.3200	0.3044	0.4289	0.6011
Learning Interval	$A_3 \bullet C_1 \bullet F_{EFY}$	0.6050[h]	0.6950[h]	0.7967[h]	0.8550[h]
Time to successfully learn	$M_4 \bullet A_3 \bullet C_1 \bullet F_{EFY}$	0.6050	0.6950	0.7967	0.8550
Steadiness	$C_2 \bullet F_{EFY}$	0.5118[c]	0.5433[c]	0.5338[c]	0.5041[c]
User Speed	$A_1 \bullet C_2 \bullet F_{EFY}$	0.3267[i]	0.3800[i]	0.5267[i]	0.4467[i]
Rate of tasks completed	$M_1 \bullet A_1 \bullet C_2 \bullet F_{EFY}$	0.3267	0.3800	0.5267	0.4467
Optimal Solution	$A_2 \bullet C_2 \bullet F_{EFY}$	0.7667[j]	0.9667[j]	0.7000[j]	0.9000[j]
Distance of mistakes made	$M_2 \bullet A_2 \bullet C_2 \bullet F_{EFY}$	0.7667	0.9667	0.7000	0.9000
Lateral Position	$A_3 \bullet C_2 \bullet F_{EFY}$	0.6200[k]	0.5400[k]	0.4600[k]	0.3800[k]
Angle of screens viewed	$M_1 \bullet A_3 \bullet C_2 \bullet F_{EFY}$	0.6200	0.5400	0.4600	0.3800
Behaviourness	$C_3 \bullet F_{EFY}$	0.6682[d]	0.5889[d]	0.7334[d]	0.7067[d]
Emotional Expression	$A_1 \bullet C_3 \bullet F_{EFY}$	0.6682[l]	0.5889[l]	0.7334[l]	0.7067[l]
Frequency of vocal cues indicated	$M_1 \bullet A_1 \bullet C_3 \bullet F_{EFY}$	0.7615	0.7615	0.8385	0.9154
Frequency of facial expressions changed	$M_2 \bullet A_1 \bullet C_3 \bullet F_{EFY}$	0.6200	0.5400	0.8200	0.7800
Frequency of postural conditions observed	$M_4 \bullet A_1 \bullet C_3 \bullet F_{EFY}$	0.6200	0.4600	0.5400	0.4200
Effortlessness	$C_4 \bullet F_{EFY}$	0.4510[e]	0.5754[e]	0.5043[e]	0.4868[e]
Cognitive Workload	$A_1 \bullet C_4 \bullet F_{EFY}$	0.3833[m]	0.4667[m]	0.3833[m]	0.5500[m]
Frequency of problems solved	$M_2 \bullet A_1 \bullet C_4 \bullet F_{EFY}$	0.3833	0.4667	0.3833	0.5500
Interface Complexity	$A_2 \bullet C_4 \bullet F_{EFY}$	0.5286[n]	0.7000[n]	0.6429[n]	0.4143[n]
Frequency of controls used	$M_4 \bullet A_2 \bullet C_4 \bullet F_{EFY}$	0.5286	0.7000	0.6429	0.4143

[a] $[((w_{EFY1})(C_1 \bullet F_{EFY}) + (w_{EFY2})(C_2 \bullet F_{EFY}) + (w_{EFY3})(C_3 \bullet F_{EFY}) + (w_{EFY4})(C_4 \bullet F_{EFY})) / (w_{EFY1} + w_{EFY2} + w_{EFY3} + w_{EFY4})]$; [b] $[((w_{TML1})(A_1 \bullet C_1 \bullet F_{EFY}) + (w_{TML2})(A_2 \bullet C_1 \bullet F_{EFY}) + (w_{TML3})(A_2 \bullet C_1 \bullet F_{EFY})) / (w_{TML1} + w_{TML2} + w_{TML3})]$; [c] $[((w_{STD1})(A_1 \bullet C_2 \bullet F_{EFY}) + (w_{STD2})(A_2 \bullet C_2 \bullet F_{EFY}) + (w_{STD3})(A_2 \bullet C_2 \bullet F_{EFY})) / (w_{STD1} + w_{STD2} + w_{STD3})]$; [d] $[((w_{BHV1})(A_1 \bullet C_3 \bullet F_{EFY})) / (w_{BHV1})]$; [e] $[((w_{EFL1})(A_1 \bullet C_4 \bullet F_{EFY}) + (w_{EFL2})(A_2 \bullet C_4 \bullet F_{EFY})) / (w_{EFL1} + w_{EFL2})]$; [f] $[((w_{UE5})(M_5 \bullet A_1 \bullet C_1 \bullet F_{EFY})) / (w_{UE5})]$; [g] $[((w_{IM4})(M_4 \bullet A_2 \bullet C_1 \bullet F_{EFY})) / (w_{IM4})]$; [h] $[((w_{LI4})(M_4 \bullet A_3 \bullet C_1 \bullet F_{EFY})) / (w_{LI4})]$; [i] $[((w_{US1})(M_1 \bullet A_1 \bullet C_2 \bullet F_{EFY})) / (w_{US1})]$; [j] $[((w_{OS2})(M_2 \bullet A_2 \bullet C_2 \bullet F_{EFY})) / (w_{OS2})]$; [k] $[((w_{LP1})(M_1 \bullet A_3 \bullet C_2 \bullet F_{EFY})) / (w_{LP1})]$; [l] $[((w_{EE1})(M_1 \bullet A_1 \bullet C_3 \bullet F_{EFY}) + (w_{EE2})(M_2 \bullet A_1 \bullet C_3 \bullet F_{EFY}) + (w_{EE4})(M_4 \bullet A_1 \bullet C_3 \bullet F_{EFY})) / (w_{EE1} + w_{EE2} + w_{EE4})]$; [m] $[((w_{CW2})(M_2 \bullet A_1 \bullet C_4 \bullet F_{EFY})) / (w_{CW2})]$; [n] $[((w_{IC2})(M_2 \bullet A_2 \bullet C_4 \bullet F_{EFY})) / (w_{IC2})]$.

A. Summary of Research

The aim of the present study was to investigate the efficiency measure involved in evaluating the efficiency of mobile applications usages. This study also extended towards the development of a model describing a mathematical-based evaluation technique for assessing the efficiency of mobile applications usage. As a result, a total number of 39 metrics and 10 attributes and 4 criterions were identified having associated towards measuring the efficiency of mobile applications usage. The applicability of the model was also tested on two experimental systems: Training Evaluation

System (PELAKAD) group where participants manipulated the cadet training tasks; and Clinical Information System (CAPSULE) group where participants manipulated the clinical delivery tasks). Analysis of the efficiency on both types of systems was assessed in terms of timeliness, steadiness, behaviourness, and effortlessness. As a result, it was concluded that the model developed and proposed in this study provides a common basis for comparison between systems as well as helping in selecting suitable product based on their needs and requirements. By producing a quantifiable measurement, the overall efficiency of mobile applications usage thus can be assessed.

B. Limitations and Future Works

In order to develop a model for measuring the efficiency of mobile applications usage, however faced with several limitations. First, measurable efficiency falls into two broad categories of subjective user preference and objective user performance measures. However, in this study efficiency is measured by analyzing only the performance indicators of effectiveness and efficiency. The absence of satisfaction, comfortable, enjoyment, safety and etc. poses a series of shortcomings. Therefore, it would be recommended to combine both performance and preference measures in future work. Second, in testing the applicability of the model, investigation was primarily conducted on the controlled experimentation in the laboratory and relatively small sample of participants containing only a part of the total number of participants were evaluated over the efficiency model. Therefore, future studies could experimentally manipulate the qualitative importance of efficiency measures. By combining both qualitative and quantitative approaches, this model might be more appreciated under a real world context of use within different human potential, technical strategies or knowledge backgrounds.

ACKNOWLEDGMENT

My thanks to Faculty of Science and Defence Technology, National Defence University of Malaysia, Centre of Research and Innovation, National Defence University of Malaysia, and Ministry of Higher Education, Malaysia.

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