



A USABILITY-BASED FRAMEWORK FOR ELECTRONIC GOVERNMENT SYSTEMS DEVELOPMENT

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ABSTRACT

In the era of globalisation, governments around the world strive to provide the best electronic Government (e-Government) systems to their people. Although the performance of e-Government systems is improving over time, their usability is still unacceptable. One of the reasons of this phenomenon is that most e-Government systems were developed without incorporating usability concerns during the development process. This study was therefore intended to identify the necessary contributing factors that should be considered during development process for ensuring the usability of e-Government systems. Based on the identified factors, the study proposed a usability-based framework for e-Government systems development that comprises three aspects: environment, system development process and product quality attributes. The framework was formulated by combining qualitative data from both theoretical and empirical work. The former involves reviews of previous usability models and standards namely Quality in Use Integrated Measurement (QUIM), Quality of Sustainable e-Government Development (QSeD), Usability Maturity of Open Source-Model (OS-UMM) and International Organization for Standardization (ISO 9241-11). On the other hand, the latter was carried out by interviewing fourteen practitioners who were involved in e-Government systems development. The collected data were analysed by using content analysis. The proposed framework was then validated through reviews by two experienced domain experts. The framework acts as a guideline for government agencies to ensure the usability of e-Government systems that they develop.

Keywords: usability, e-government, system development quality.

INTRODUCTION

Internet revolution allows people to do tasks faster regardless of place and time. It affects social life and opens up a new medium of communication for individuals and organisations. Today, the governments around the world have become a part of Internet revolution through Electronic Government (e-Government) initiatives.

E-Government endeavours are mainly supported by e-Government systems. The systems bring the people closer to the government via essential online information and transaction services. In order to ensure the effectiveness of government's services to its people, e-Government systems are required to meet and satisfy the people's needs.

While many government agencies have succeeded in developing e-Government systems, most of them failed to achieve their real needs and the expected quality [1] [2]. This failure is due to the absence of attention towards the quality aspects especially usability [3]. In particular, there is a lack of adoption and guidance on usability concerns in developing e-Government systems.

With regards to e-Government systems development, it was found that most system developers focused only on functional needs [4] and the usability requirements were rarely considered during user testing [5]. In fact, only certain usability concerns were

emphasised during system development such as the architectural design and performance [3], [6], [7], [8], [9]. As a result, the developed systems are barely used by their intended users.

One of the causes for these phenomena is that system developers are not being properly guided towards usability. Although previous studies have provided some guidelines, they are perceived to be mutually exclusive and do not complement each other [10]. In fact, they were developed for specific domains, thus reduce their applicability [11], [12], [13]. The lack of guidance has resulted the usability concerns are not being considered and embedded in e-Government systems development.

The above statements indicate that there is a need for a holistic guideline or framework that considers usability during development process for e-Government systems. To date, such a framework is almost non-existence [14]. Hence, this study aimed to address this concern.

RELATED WORK

Electronic Government (e-Government) is a medium of interaction between the government and external customers as well as from the government to itself. E-Government can be defined as the use of web-based information technology (IT) that allows its customers to access government information and services



efficiently. E-Government customers include the government, the business community and the people.

E-Government advancements started at the end of 1990s with an emphasis on the use of IT in government [15]. E-Government is now more focused on the external benefits such as services to the people, decision making, processes and values in the services [16]. Countries around the world benefited from e-Government particularly in improving the quality of service to its customers.

In principle, e-Government shall provide equal access to its services by all [17]. Although governments are connected to the people through Internet, it does not guarantee that the services can be accessed as required especially the disabled [18]. Previous studies on e-Government have found that usability concerns were ignored [3]. The evaluation made on several e-Governments based on Web Content Accessibility Guidelines (WCAG) revealed a number of usability issues [3], [6], [7], [8], [9], [10]. Among others, the issues are speed, broken links, lack of interactive features and accessibility features. This phenomenon happens because the usability models that can be referred by developers when developing e-Government are limited. Even some do exist, they emphasis mainly on performance aspect [19]. According to several reports on e-Government [7], [20], there is a need to formulate specific usability models to improve the quality of e-Government systems.

Usability is defined as the extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency and satisfaction in a particular context of use [21]. Usability assesses how easy a user interface is used or refers to and how to improve the simple-to-use design process [22]. There are five components of usability which are easy to learn, effective, easy to remember, user error and user satisfaction. Usability is also identified by five key attributes namely easy-to-use, performance, less error rate, persistency and attitude of consumers [23]. Despite various definitions of usability, it basically means how easy it is to use an equipment or software in attaining a specific purpose in the context of a particular application.

Usability is influenced by the individual, technology and the tasks to be performed. Thus, usability plays an important role in identifying the characteristics of software product quality, satisfying customer needs, determining the software design and affecting the value of a product. The measurement of usability is based on users' experience when they interact with software products or systems, either through website, software application, mobile technology or a variety of consumer devices. In other words, usability is a quality attribute that assesses how easy an interface is used.

There are several organisations that provide e-Government ratings such as United Nation Public Administration Network (UNPAN) [24], Brown University (BROWN) [25], Waseda University (WASEDA) [26] and World Economic Forum (WEF)

[27]. The ratings have encouraged the governments to improve the quality of their e-Government services, particularly on usability concerns. Unfortunately, the models that can be used to evaluate and enhance the usability of e-Government systems are limited. The following paragraphs briefly discuss the relevant models.

a) International Organization for Standardization

9241 (ISO 9241): ISO 9241-11 is a quality model developed for usability in terms of human-computer interaction. Usability framework in ISO 9241-11 consists of the objective, the context of use, tasks, equipment and environment that cover three attributes which are effectiveness, efficiency and satisfaction [21]. ISO 9241-11 however does not address important usability attributes recommended by other usability models such as the ability to learn [28]. ISO 9241-11 recommends usability to be integrated in systems development through acquisition, user requirements, design, development and communication processes. On the other hand, there is no clear explanation on how the mandate of usability design involving users should occur in development cycle. The model generally agreed that activities such as user requirements and design contribute to the development of a product that is simple to use [29], besides the development methodology [30].

b) Quality in Use Integrated Measurement (QUIM)

model: The original version of QUIM was developed in 2001 based on ISO 9241-11 [11]. The model consists of 7 usability attributes, which are effectiveness, efficiency, satisfaction, productivity, security, international and accessibility [31]. The latest version of QUIM was developed not only based on ISO standards but also traditional software quality models and usability measurement models [11]. Among the models and standards used in QUIM include ISO 9241 [21], ISO 9126 [32], McCall [33], Boehm [34], Model Metrics for Usability Standards in Computing (MUSIC) [35] and Semi-Automated Interface Designer and Evaluator [36]. QUIM found several lacks in those models and standards and thus combined them in a complementary manner. QUIM is therefore a hierarchical model of usability measurement consisting of 10 factors, 26 sub-factors and 127 metrics. The 10 revised usability factors or attributes include efficiency, effectiveness, productivity, satisfaction, learnability, safety, trustability, accessibility, universal and usefulness.

c) Usability Maturity of Open Source-model (OS-UMM):

OS-UMM suggested factors that help to improve the usability of open source software based on end-user perspective [13]. OS-UMM used QUIM as the guidance and concluded four key usability attributes, namely user expectations, usability bug reporting and fixing, interactive help features and usability learning.



d) The Quality of Sustainable e-Government Development (QSeD) model: The model is used as a tool to improve administrative processes and service delivery. Its success depends on the quality of products produced and how it is used by governments, citizens and business community. This model adopted the Model for e-Government Success [1], which was developed to evaluate the success and effectiveness of information systems [37]. The model also employed International standards such as ISO/IEC 9126, ISO 9241 and COBIT 4.1. It identified the following e-Government quality attributes: functionality, reliability, usability, efficiency of process quality, accuracy, timeliness, relevance, precision, completeness of information quality and the effective communication for service quality. This model proposed four key elements, which are stakeholders and policies, ICT, development methodology and environment.

METHODOLOGY

This study aimed to answer the following research questions:

- a) What are the factors that contribute to the usability of e-Government systems from the development perspective?
- b) How the factors can be combined in the form of an integrated usability-based development framework for e-government systems?

This study employed qualitative method because it is appropriate to answer the above RQs. The method was chosen because it allows researchers to understand and investigate the research topic in depth and detail. The purpose of this study was to identify the factors that influence the development of usable e-Government systems. These factors were then used as the bases for the proposed usability-based development framework for e-Government systems. The specific qualitative techniques used in the study were reviews and interviews. The sampling was purposeful.

Reviews involve the process of identifying and examining secondary data sources. It allows the identification of factors from references that are appropriate in the context of study such as journals, books, conference proceedings and technical reports. The searching was made by using the following keywords: "usability AND e-Government", "usability model", "usability" or "ease-of-use" and "factor". Among the databases that were used in the searching include IEEEExplore, Emerald, ISI Web of Science, ProQuest, Science Direct and Springer. This study also used

snowball technique in which investigation was made to the relevant publications based on the reference lists. As a result, the study found four usability models and standards that are relevant to e-government systems, namely ISO 9241, QUIM, QSED and OS-UMM.

The interviews concerns face-to-face verbal conversation with the suitable informants. This study interviewed fourteen officers who were involved in e-government systems development. The interviews were in the form of semi-structured. The questions were formulated based on the reviews of previous usability models and standards, as described above. In addition, a set of open-ended questions were prepared to acquire informants' thoughts and opinions relating to the process. The open-ended questions were deemed as necessary as they helped in getting informants' perspectives without any constraints. Prior to conducting the interviews, the interview protocol was tested in a pilot study. The interview protocol was then modified as needed. The informants were interviewed individually at their respective workplace within approximately one hour. The interviews were conducted over a span of three months. The audio-recorded interviews data were transcribed and organised in textual forms. They were then properly stored for later analysis and interpretation.

The collected data from both reviews and interviews were transcribed and analysed by using content analysis. Content analysis is a research technique for making replicable and valid inferences from text to the contexts of their use, in a way of providing knowledge, new insights, a presentation of facts and a practical guide to action. To initiate the process of content analysis, the coding procedure was conducted. The coding procedure started by giving a label to each text segment. A text segment may range from few words to a paragraph. The goal of coding is to rearrange and integrate the related words, sentences or paragraphs together in order to draw a meaningful description about the data. The data then form a major idea, which represents a specific theme. In this study, the themes are indeed the factors that influence the development of usable e-Government systems.

To validate the proposed framework, expert reviews was conducted. There were two experts involved in the validation. They were experienced managers with at least 20 years of experience in e-Government systems development. In general, the experts checked the accuracy of the identified factors, the suitability of the selected elements and their interrelations in the framework. The data gathered was analysed using contents analysis [38]. The results of the analysis were used to finalise the proposed framework. Figure-1 shows the phases and activities involved in this study.

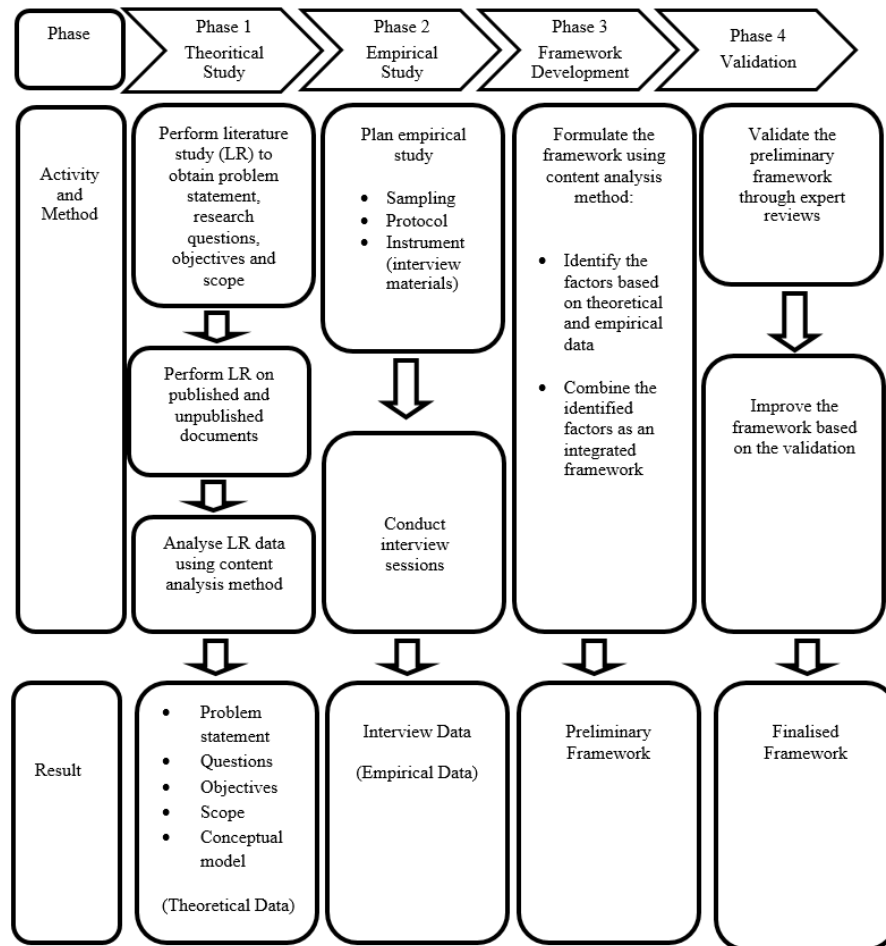


Figure-1. Research methodology.

RESULTS AND DISCUSSIONS

The framework consist of three key aspects namely environment, system development process and product quality attributes. These three aspects are connected to each other and have certain influences towards the usability of e-Government systems. The framework depicts how an e-Government system's product quality attributes, which include functionality and usability, can be achieved through usability-based system development process. The process needs to be supported by environment factors namely people, procedure and technology, as shown in Figure-2 below.

There are relationships between factors and relationships between sub-factors in the framework. People comprise system developer and system user who need to interact with each other. System users together with system developers need to be actively involved during the system development process. System users have direct influence on the e-Government system (product) quality by ensuring the fulfilment of the

attributes. Besides people, the factors from the environment namely procedure and technology, influence the system development process.

The system development process comprises planning, requirements analysis, design, coding and testing as well as implementation phases. The planning phase influences requirements analysis. Later, the specified requirements determine design, coding and testing as well as implementation of the system. The phases happen in sequence but could be iterative. For example, if some inaccuracies are found during design or coding, the requirements analysis-design-coding cycle will be repeated. The completion of this development cycle ensures the accomplishment of product quality attributes.

The product quality attributes are the output of the system development process. It consists of functional and usability attributes which complement and require each other. Below are the detailed explanations of each factor.

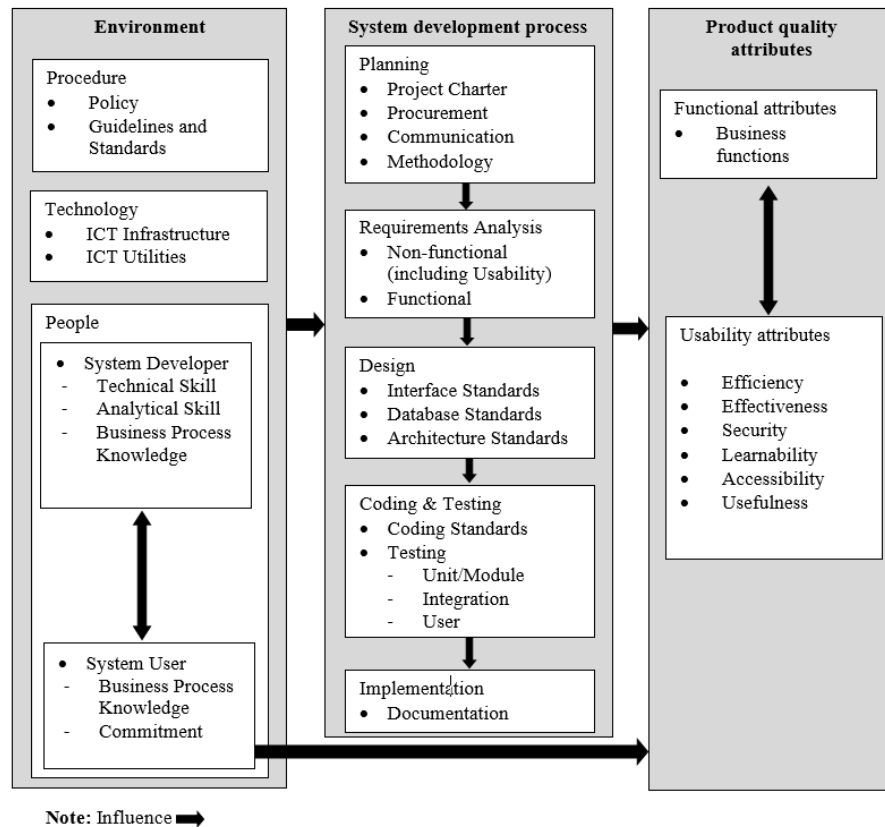


Figure-2. A usability-based framework for e-government systems development.

Environment

Environment is the situation or work area of a system. In the proposed framework, the environment is divided into three factors which are procedure, technology and people. These three factors influence the development process of e-Government systems. The following paragraphs describe the factors and their respective elements.

a) Procedure

Procedure is the way of performing certain tasks or doing something. This study identified two sub-factors concerning procedure, which are required to support e-Government system development process:

- i) **Policy:** A plan of action that has been officially consented as the basis to make organisational decisions. Among the relevant policies that need to be referred in developing e-Government systems are ICT Policy and ICT Security Policy.
- ii) **Guidelines and Standards:** Government instructions and requirements that need to be referred or complied during the development process by system users and system developers. The guidelines and standards

include documents related to government ICT requirements and business processes.

b) Technology

Technology is a method or process of handling things. In this study, the technology used is considered as the tool to develop e-Government systems. There are two technologies which influence e-Government system development and its usability:

- i. **ICT infrastructure:** The information and communication technology facilities that are required to implement e-Government systems. The required ICT infrastructure encompasses network, hardware, software, servers and broadbands. For example, the system developers needs to ensure that the servers being used can accommodate multiple and concurrent users' access. Besides that, they also have to ensure that the basic facilities to run the system are compatible. For example, the hardware must be well-suited with the software and network used.
- ii. **ICT utilities:** Tools that are used to develop e-Government systems. System developers use ICT utilities to complete various development tasks. Some



examples of ICT utilities are modelling, design, coding and testing tools.

c) People

People are categorised into two main groups:

- a. **System user:** An individual or people who are using the system to complete certain tasks. System users include the government staffs who are also the process owners. System users need to possess business process knowledge and right attitude. Knowledge in business process is essential to assist in delivering system requirements accurately, meanwhile the commitment is vital to ensure the process continuity in implementing the system. This is because the system users need to be actively involved throughout the development process. System users' involvement is important to ensure that the system is developed according to their needs from the start.
- b. **System developer:** The staff who are involved in system development process. Their roles begin from requirement analysis, design, coding and testing as well as implementation. System developers need to have technical skill, analytical skill and business process knowledge. Technical skill is required during system design, coding and testing as well as implementation. The analytical skill assists system developers to understand and analyse system requirements obtained from system users. System developers also need to understand business process so that they can acquire and analyse accurate requirements that satisfy system users' needs.

The factors stated above are in line with the emphasis given in ISO 13407 (1999), which is the user and organisation are in actual fact, have an influence on system development process. In addition, system developers need to understand user requirements and context of system usage.

System development process

To produce a usable e-Government system, the development process needs to have a series of planned activities supported by clear procedure and suitable technologies. The process also needs to involve system users who need to interact with system developers starting from the planning process until the implementation process.

a) Planning

- a) **Project charter:** Without project management, system development is susceptible to fail. There is a risk that the developed system does not meet its users' requirements. Thus, a project charter needs to be prepared. It contains the related information on the project such as scope, objectives, organisation, roles and responsibilities, the project manager authority,

financial and implementation schedule. It is a document that needs to be comprehensive and endorsed by the parties involved in the system development. The project charter is the main project document that needs to be referred and updated based on the project requirements. The roles of system developers and system users' involvement need to be stated explicitly so that the system objectives to include usability features could be accomplished. The project charter acts as a guide and reference for the system development project team.

- b) **Procurement:** E-Government systems that are developed internally is believed to be more usable compared to externally developed systems. This is because system users have direct contacts with system developers. Systems that are developed externally require effective project management.
- c) **Communication:** Communication during system development is a factor that cannot be undermined. Planned and effective communication enables the development process to become more organised and directed. Furthermore, misunderstandings between system users and system developers can also be avoided. System developers thus need to establish effective communication channels at each system development phase. The communication channels are in the form of meetings, discussions and reviews. This factor is supported by ISO 13407, which highlighted that communication between users and the related parties is important particularly during requirement elicitation to ensure the usability of the system to be built.
- d) **Methodology:** Based on the empirical study, there are two main approaches used in the development of e-Government systems namely Waterfall and Agile. Waterfall methodology is mainly used when the systems are developed by internal teams while Agile methodology for outsourced teams. Another method is prototyping, which is used when the development is totally new, where the requirements are not adequately defined.

The Waterfall is regarded as the most suitable methodology for developing e-Government systems, as most government business processes involve definite instructions, objectives and solutions. The user and system requirements of such systems are stable and seldom require major modification. The Agile methodology and prototyping are recommended only if the development is a new initiative with unclear user and system requirements, which requires constant involvement from system users and involves major changes.

b) Requirements analysis

The requirements analysis phase describes what needs to be done by the system. It is an important phase where system developers acquire requirements from



system users. The requirements are obtained via elicitation techniques such as interviews, observation, task analysis and brainstorming. The output of this phase is System Requirement Specification (SRS), which specifies what the system should have or do. In this phase, the system developers should not only foresee the system functions (functional) but also the supporting functions (non-functional) that ensure the smooth functioning of the system, where usability requirements are considered as one of them. A prototype may also be developed to enable system users to understand and evaluate the requirements.

c) Design

The design phase involves activities that formulate the detailed specification of three main system components, which are interface, database and architecture. System developers are responsible for preparing the designs for interface, database and architecture based on SRS. There are certain standards that need to be adhered to during this process. The interface standard, for example, ensures system uniformity and facilitates the system usage. The database standard outlines the database structure and security while the architecture standard defines the spectrum of system environment. After the design specification is approved, system developers continue with system coding and testing.

d) Coding and testing

The coding phase involves developing the system by using certain programming languages and tools. It is a phase whereby system developers transform the design specification to a verifiable system. For uniformity and maintenance purposes, system developers are required to conform to specific coding standards. The testing phase is where the system faults are traced. Based on the nature of e-Government systems, there are three types of testing:

- a) Unit test, which certifies each system module.
- b) Integration test, which tests integration between system modules and the entire system.

- c) User test, which tests the user acceptance towards the developed system.

Unit test is normally done by the individual system developer who is in-charged of that module. Integration test involves an independent team or testers whereas user test involves system users. Testing that are executed together repeatedly with system users can identify any usability issues. The testing also needs to be executed by staff who have knowledge in the business process.

e) Implementation

This phase concerns system installation and operation, which is implemented after the system has been tested and ready to be used by system users. One important task during this phase is preparing and compiling system documentation. System documentation is a collection of system materials, which are referred by system developers and system users. Apart from that, users' feedback on the product quality attributes (functionality and usability) can be obtained and documented. The usability can be evaluated by system users based on six usability attributes described in the following section.

Product quality attributes

The product of system development process is the e-Government system. The framework outlines the product quality attributes, which consist of functional and usability attributes. The functional attribute describes the business functions that need to be implemented in the system. The usability attribute on the other hand is one of the non-functional requirements that supports the functional requirements. Based on the analysis, the framework classifies the product usability attributes into six main categories, which are relevant to e-Government systems. They are efficiency, effectiveness, learnability, security, accessibility and usefulness. Table-1 below explains the usability attribute, definition and examples of criteria.

**Table-1.** Definitions of usability attributes.

Attributes	Definition and examples of criteria
Efficiency	The ability of a product to enable user to use suitable sources in the context of certain usages. Example of criteria: Time required to show or display a page.
Effectiveness	The ability of a product to enable user to achieve certain tasks in an accurate manner. Example of criteria: Making the right and effective decisions.
Learnability	The ability of a product to enable user to feel that he/she is productive and learns new functions fast. Example of criteria: The product that provides assistance with clear guidance.
Security	Technical and administrative protection towards system to avoid intrusions, destructions or exposures either intentionally or otherwise. Example of criteria: To ensure that only valid users are able to use the system and the right data code is entered into the system.
Accessibility	The ability of a product to accommodate user's preferences and personality. Example of criteria: Users are able to change certain features of the system such as text, colour and language.
Usefulness	The ability of a product to enable user to resolve real problems. Example of criteria: The user can use certain utility to support his/her task.

CONCLUSIONS AND FUTURE WORK

This study has identified the factors that should be considered during development process for ensuring the usability of e-Government systems. The factors were acquired based on theoretical and empirical studies, which were then conceptualised as a framework. The framework has identified six usability attributes that are necessary for e-Government systems. The attributes are efficiency, effectiveness, learnability, security, accessibility and usefulness.

A system's usability cannot be accomplished without a planned development process that embeds usability concerns from the start. Thus, this study outlines the factors and elements that are necessary to be incorporated in the development process to ensure the usability of e-Government systems. The development process needs to be supported by three environment factors, namely people, procedure and technology. While people are the key players who run the initiative, the procedure defines the directions to be followed. The technology on the hand is the mediums to achieve the aims. By following the development process together with the support from the environment, an e-Government system that is efficient, effective, learnable, secured, accessible and useful can be produced.

In short, the proposed framework has enhanced theoretical and practical knowledge related to the e-Government system usability. The framework is able to assist system developers in developing an e-Government system that has better usability levels. It also defines the usability attributes that could be used in measuring e-Government systems. This study focuses on general aspects of e-Government system development. Therefore, further studies are required to refine the development process and relate them explicitly with the recommended

six usability attributes. The framework also needs to be tested in other government settings.

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