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Refinement of the ISO 9126 Model for Evaluating Software Product Quality in e-Book

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ABSTRACT

Despite the widespread use of e-Book in education, there is yet a standard framework for evaluating the quality of software products in e-Book. Research efforts mainly focus on technological breakthroughs and limited attention has been given to the evaluation of software product quality. As such, this paper aims to propose a refinement of the ISO 9126 model for evaluating software product quality in e-Book. Popular *Software Quality Models* are reviewed including McCall, Boehm, FURPS, Dromey and ISO 9126. Refinements to ISO 9126 resulted in the identification of five quality characteristics (*Functionality, Reliability, Usability, Efficiency, Portability*) and 16 sub-characteristics (*Suitability, Accurateness, Security, Interoperability, Maturity, Fault Tolerance, Recoverability, Understandability, Learnability, Operability, Attractiveness, Time Behavior, Adaptability, Installability, Coexistence, Replaceability*). There are two contributions of this work: a Software Quality Model for e-Book; and the identification of quality metrics to support the evaluation of software product. The refined model provides a formal method for evaluating software product quality in e-Book and the quality metrics serves as a foundation for the development of survey instruments and computer support system. It is hoped that this work would spark interest for the development of better e-Book applications.

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INTRODUCTION

Advancement in computing technology has witnessed a revolution with the acceptance of *Electronic Book* (e-Book) as a vital part in the education system. It has transformed traditional classroom to digital learning environment. Several studies recognize the importance of e-Book as a tool to facilitate teaching and learning (Yager & Szabo, 2011). As a tool, e-Book produces positive effects on student performance and teacher productivity (Roslina, W., Fahmy, S., Yaacob, A., Haslinda, N., & Fariha, Z., 2012; Sivin and Bialo, 1997).

The e-Book program in Malaysia began in 2009 with the distribution of e-Book to primary school children in the state of Terengganu. Its aim is to support learning activities and expose student to *Information and Communication Technology* (ICT). More than RM50 million has been spent by the government since this program started. Despite the amount of investment, there has been little attention given to the effort of evaluating and maintaining software product quality in e-Book.

Comprehensive specification and evaluation of software product are key factors in ensuring quality. This can be achieved by defining appropriate quality characteristics, taking into account of the purpose of the software product (Fitzpatrick, 1996; Lew, 2012). It is essential that relevant quality characteristics is specified and evaluated, using validated and/ or accepted metrics (Landoni, 2010). To evaluate the quality of the end-product, a set of a quality characteristic that describes the product is required. As such, this paper aims to propose a refinement of the ISO 9126 model for evaluating software product quality in e-Book.

2. Literature Review:

This section presents an overview of e-Book and Software Quality models. The aim of this review is two-fold: to identify the software products in e-Book; and to identify important quality characteristics in existing quality models that can be adapted and/or adopted in the evaluation of the products.

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e-Book:

The first instance of 'electronic book' is found in 1985 (Reilly, 2003) although some authors argue that e-Book started as early as the late 1940s with the introduction of 'la Enciclopedia Mecánica' in 1949 – a system that allows readers 'to stop at a specific page' and 'zooming in a particular area of the text' (Roslina, W., Fahmy, S., Fariha, Z., Haslinda, N., Yacob, A., Sukinah, N., & Suhana, N., 2013). Early e-Books include *Dynabook* and *Data Discman* before the advances in computer science witness the emergence of *Barnes & Noble Nook*, *Amazon Kindle*, *Apple iPad* and *Google eBooks*. Modern e-Books are computerized representations of physical books. The content can be as simple as scanned pages to a more 'lively' one, with the incorporation of animation and sounds. Some e-Books are also integrated with assessment tools and dedicated learning environments such as the e-Book in Malaysia (Roslina, W., Fahmy, S., Fariha, Z., Haslinda, N., Yacob, A., Sukinah, N., & Suhana, N., 2013).

The Malaysia e-Book is based on the *Intel Classmate PC*, produced for the *World Ahead Program* (Roslina, W., Fahmy, S., Fariha, Z., Haslinda, N., Yacob, A., Sukinah, N., & Suhana, N., 2013). The e-Book is used in conventional classroom teaching (off-line), test administration (on-line), and in smart classrooms. Apart from the MS Windows and MS Office applications, the e-Book is shipped with five specific applications: *Digital Textbook*, *MyKamus*, *Fasohah Jawi*, *Fardhu Ain* and *Digital Quran*. *Digital Textbook* is a digital copy of the official textbooks in the Malaysia school system. There are 14 titles altogether including English, Mathematics and Science. *MyKamus* is a dictionary application that contains more than 85,000 English and Malay words. Translation can be done from English to Malay and vice versa. *Fasohah Jawi* is an application for learning *Jawi*, the traditional Malay script based on Arabic alphabets. *Fardhu Ain* is a multimedia application for learning the fundamentals of Islamic teachings such as prayer and *doa*. *Digital Quran* is a digital copy of the Quran, listing all 114 *surahs*. This multimedia application enables users to browse through the *surahs* where text, sound and translation (to Malay) are incorporated to facilitate learning.

Software Quality Model:

Software quality model can be described as 'a set of characteristics and the relationship between them, which provide the basis for specifying quality requirements and evaluating product quality' (Al-Qutaish, 2010). Popular models include *McCall* (McCall, J. A., Richards, P. K., & Walters, G. F., 1977), *Boehm* (Boehm, B. W., Brown, J. R., Kaspar, H., Lipow, M., McLeod, G., Merritt, M., 1978), *FURPS*, *Dromey* (Dromey, 1995) and *ISO 9126* (ISO 9126, 2001). The *functionality* of software product is not considered in McCall; Boehm fell short in measuring quality characteristics; while *FURPS* does not address product portability. Since *ISO 9126* is based on previous models, it is more complete and covers almost all critical characteristics including structure, evaluation criteria, and relationships (ISO 9126, 2001).

ISO models including the *ISO 9126* and *ISO 25010* (Rafique, I., Lew, P., Abbasi, M. Q., & Li, Z., 2012) can be used to support specification and evaluation of software from different perspectives including acquisition, requirements, development, and quality assurance. *ISO 9126* distinguishes different viewpoints for software product quality namely *Internal Quality*, *External Quality*, and *Quality in Use*. *ISO 25010* combines internal and external quality models as *Product Quality*. Based on these views, *ISO 9126* is chosen for this work. In addition, software product evaluation based on *ISO 9126* has been applied to the education domain as reported in the previous work (Behkamal, B., Kahani, M., and Akbari, M. K., 2009; Valenti, S., Cucchiarelli, A., and Panti, M., 2002; Chua and Dyson, 2004).

ISO 9126:

ISO 9126 is an important standard for software quality assurance. The fundamental idea is specifying and evaluating software product in terms of internal and external qualities and their connections to quality attributes (*ISO 9126*, 2001). In *ISO 9126*, the totality of quality attributes is classified into a hierarchical tree structure of characteristics and sub-characteristics. It specifies six characteristics: *Functionality*, *Reliability*, *Usability*, *Efficiency*, *Maintainability* and *Portability*; which are further divided into 21 sub-characteristics. The main advantage of *ISO 9126* is the characteristics are applicable for every kind of software while providing consistent terminology (Behkamal, B., Kahani, M., and Akbari, M. K., 2009; Quirchmayr, G., Funilkul, S., & Chutimaskul, W., 2007). It also covers critical characteristics such as hierarchical structure; criteria for evaluation; and simple definitions.

ISO 9126 does not prescribe specific quality requirements for software product, but instead describes a quality model, which can be applied to any software. This standard includes the user view and introduces the concept of *Quality in Use* (Stefani, 2004) - quality of the software whilst operating in its environment as seen by the user rather than the properties of the software itself. User satisfaction is often used to determine software success.

3. Refinement of the ISO 9126 Model:

The role of ICT in the academic domain specifically e-learning and courseware is still evolving (Behkamal, B., Kahani, M., and Akbari, M. K., 2009; Valenti, S., Cucchiarelli, A., and Panti, M., 2002; Chua and Dyson, 2004). However, research efforts in the adaptation of ISO standards for e-Book are limited (if any), leading to the novelty of this work. It is interesting to note that although ISO 9126 does not prescribe specific quality requirements, it does however, define a general framework for the evaluation of software quality.

The generality of ISO 9126 means further analysis and mapping (of characteristics) are required before it can be fully adapted to e-Book. It is possible to classify quality characteristics according to academic domain (Chua and Dyson, 2004). Due to the fact that none of the characteristics can be measured directly, they should be assessed in terms of the objectives (of sub-characteristics) and criteria of the e-Book (Padayachee, I., Kotze, P., & van Der Merwe, A., 2010).

Functionality, Reliability, Usability, Efficiency and Portability characteristics are chosen as they are highly dependent on the application domain to which e-Book belongs to (Fahmy, S., Haslinda, N., Roslina, W., & Fariha, Z., 2012; Haslinda, N., Fahmy, S., Roslina, W., Yaacob, A., Aziz, N., Sulaiman, N., & Fariha, Z., 2012). *Functionality* is chosen as it is dependent on the application domain while *Reliability* concerns information presentation and content in academic product (Chua and Dyson, 2004). *Usability* is included as it refers to the capability of the software product to provide usable function to achieve its aim (Chua and Dyson, 2004).

Maintainability is excluded since it is usually evaluated by the developer or third party vendor with access to the source code (Saini, R., Dubey, S. K., & Rana, A., 2011). Although most software product perceives *Maintainability* as an important quality characteristic, it is only evaluated in the early stages of development (Saini, R., Dubey, S. K., & Rana, A., 2011). This is in line with software product evaluation in the academic domain, where *Maintainability* and *Portability* are not seen as significant characteristics. However, *Portability* is included in this work as software products need to co-exist with existing ones (Chua and Dyson, 2004).

The refined model for e-Book is illustrated in Fig.1, listing the characteristics and sub-characteristics based on the ISO 9126 model.

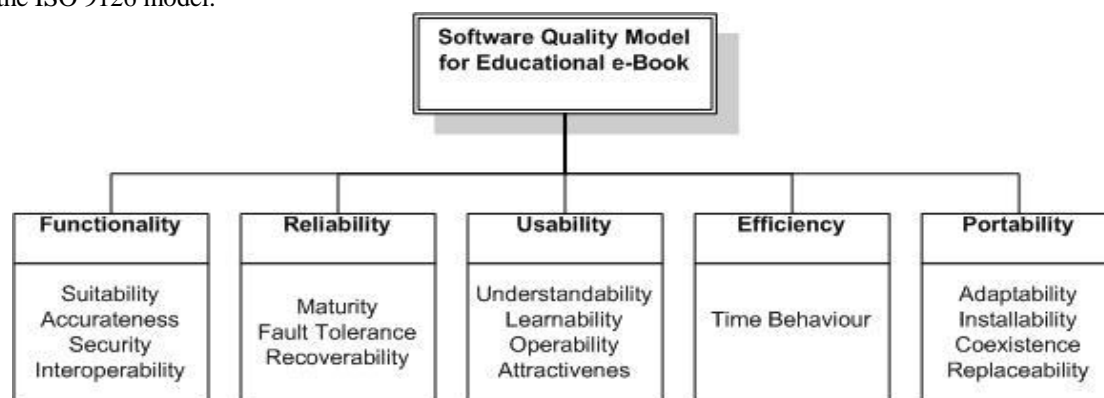


Fig. 1: Software Quality Model for e-Book.

Functionality:

Functionality is 'the capability of the software to provide functions which meet the stated and implied needs of users'. Taking e-Book into context, this characteristic can be evaluated through functions and services provided to the user. These include the requirements for basic book metaphor, navigational tool, and search engines. Appropriate sub-characteristics for e-book are *Suitability, Accurateness, Security* and *Interoperability*. Table 1 provides quality metrics for *Functionality* and its sub-characteristics.

Table 1: Functionality Quality Metrics.

Sub-Characteristics	Quality Metrics
Suitability <i>Can the software perform the required tasks?</i>	The extent to which e-Book : <i>Provides an appropriate set of function and objectives such as a basic book metaphor, electronic functions and physical objects.</i>
Accurateness <i>Can the software produce expected results?</i>	The extent to which e-Book: <i>Provides expected results or effects for specified task and objectives such as navigational tool, search engine and cross referencing.</i>
Security <i>Can the software interact with other system?</i>	Security measures in e-Book: <i>Maintaining the confidentiality of information including authentication, login procedure, display of sensitive data, password protection and user privileges.</i>
Interoperability <i>Is the software equipped with security measure?</i>	The extent to which e-Book: <i>Limit access from other software and provide content to digital libraries.</i>

Reliability:

Reliability is ‘*the capability of the software to maintain a specified level of performance*’. In e-Book, this characteristic deals with the presentation of information and consistency of the content. *Maturity*, *Fault Tolerance* and *Recoverability* are identified as sub-characteristics for *Reliability* in e-Book (Table 2).

Table 2: Reliability Quality Metrics.

Sub-Characteristics	Quality Metrics
Maturity <i>Can most of faults be eliminated over time?</i>	Reliability of e-Book: <i>In terms of frequency of software failure and error-free functions.</i>
Fault Tolerance <i>Can the software handle errors?</i>	Fault tolerance of e-Book: <i>In response to invalid input and the ability to maintain performance in the event of software faults.</i>
Recoverability <i>Can the software resume working and restore data?</i>	Recoverability of e-Book: <i>Resuming work soon after failure, quickly recovering from failure and warn user to take action once error is recognized.</i>

Usability:

Usability is ‘*a set of attributes that measure the perception of system utility and satisfaction for a stated or implied set of users*’ (Stefani, A., Vassiliadis, B., & Xenos, M., 2006). *Usability* in e-Book involves *Understandability*, *Learnability*, *Operability* and *Attractiveness* as its sb-characteristics (Table 3).

Table 3: Usability Quality Metrics.

Sub-Characteristics	Quality Metrics
Understandability <i>Can the software be understood easily?</i>	The capability of e-Book in providing: <i>Well functioning buttons, consistent layout/ templates, consistent use of terms, consistent positioning of error messages, consistent interface task, which can be easily understood, and self-explanatory of contents and buttons.</i>
Learnability <i>Can the software be learnt easily?</i>	Learnability of e-Book with regards to: <i>Learning to use the software, exploring new features or functions by trial and error, use of commands, navigation tools and search tools, and performing tasks, use of the table of content, use of online help messages and clarity of instructions.</i>
Operability <i>Can the software be operated with minimal effort?</i>	Operating e-Book: <i>In finding required information (such as using table of contents), organization of information, screen sequence, and performing tasks (such as information searching, use of navigation tool, etc).</i>
Attractiveness <i>Does the software have an appealing interface?</i>	Attractiveness of e-Book: <i>From the point of user interface, templates and multimedia in a software product.</i>

Efficiency:

Efficiency is ‘*the capability of the software in providing appropriate performance, relative to the amount of resources used*’. Efficiency is a complex concept which offers both conceptual challenges as well as implementation difficulties. It refers to how well the e-Book fulfills its purpose(s). *Time Behavior* is the only sub-characteristic for *Efficiency* in e-Book as illustrated in Table 4.

Table 4: Efficiency Quality Metrics.

Sub-Characteristics	Quality Metrics
Time behavior <i>Does the software behave in a timely manner?</i>	The capability of e-Book to: <i>Providing appropriate response time (from help function/ navigational tools, search function, next and previous button), providing appropriate processing time (loading time), handling large documents, locating operations and information quickly, performing a sequence of operations with economy of motion (number of mouse clicks to get the next page).</i>

Portability:

Portability is ‘*the capability of the software product to be transferred from one environment to another*’. Software products in e-Book should be easily transferred to another environment if the need arise (new technology, etc). Appropriate sub-characteristics include *Adaptability*, *Installability*, *Coexistence* and *Replaceability* (Table 5).

This section has discussed and proposed a refinement of the ISO 9126 model for e-Book. The refined model provides a formal method for evaluating software product quality in e-Book. The quality metrics in Tables 1-5 could serve as a foundation for the development of survey instruments and computer support system for e-Book.

Conclusion and Future Work:

This work has proposed a refinement of the ISO 9126 model for evaluating software product quality in e-Book. A total of 5 quality characteristics and 16 sub-characteristics have been identified namely *Functionality*, *Reliability*, *Usability*, *Efficiency*, and *Portability*; and *Suitability*, *Accurateness*, *Security*, *Interoperability*,

Maturity, Fault Tolerance, Recoverability, Understandability, Learnability, Operability, Attractiveness, Time Behavior, Adaptability, Installability, Coexistence and Replaceability, respectively. There are two contributions of this work: A Software Quality Model for e-Book; and the identification of quality metrics to support the evaluation of software product in e-Book.

Table 5: Portability Quality Metrics.

Sub-Characteristics	Quality Metrics
Adaptability <i>Can the software be adapted easily?</i>	Ability of e-Book in terms of: <i>Adapt to different hardware or OS platforms without additional effort.</i>
Installability <i>Can the software be installed easily?</i>	Ability of e-Book in terms of: <i>The effort needed to install the software product in a specified environment other than the initial platform.</i>
Coexistence <i>Can the software work with existing software system?</i>	Ability of e-Book in terms of: <i>The degree of conformance of the product to standards or conventions related to portability.</i>
Replaceability <i>Can the software be replaced with similar product?</i>	Ability of e-Book in terms of: <i>The opportunity and effort to use software product as a replacement for another application or older software.</i>

Directions for future works include empirical assessments on the effects of e-Book; a computer application for product quality evaluation; the application of the model in other domains; and refinement of ISO 25010 for e-Book. It is hoped that this work would spark interest for the development of better e-Book applications.

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