

Evaluating the Quality of Software in e-Book Using the ISO 9126 Model

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Abstract

Electronic Book or e-Book has become a new medium in education. An important consideration of e-Book in the education system is the quality of software that are shipped with it. The term 'e-Book' is ambiguous at best, and has been used interchangeably with netbook, mini laptop and e-reader to name a few. This paper is interested in determining an appropriate model for evaluating the quality of software in e-Book. It is argued that in order to reap the best possible outcome from e-Book (and on-line learning), quality of the software used should be of 'acceptable' standard. Past research efforts are reviewed and a comparison is made to identify best quality 'characteristics' that should be used in the evaluation of e-Book. An extension of the ISO 9126 model for assessment is proposed, categorizing five quality characteristics for e-Book.

Keywords: *e-Book, Software Quality Model; ISO 9126, Technology and Education*

1. Introduction

The exponential growth of *Information and Communication Technology* (ICT) has changed the education system from traditional classroom teaching to online examination administration. Studies have revealed that ICT has a positive effect on students' performance and teachers' productivity [1, 2]. Recently, advancement in computing technology has witnessed a revolution with the use of *Electronic Book* (e-Book) in education. Several countries including the United Kingdom and Canada have incorporated e-Book in compulsory education. In Malaysia, the state of Terengganu is leading this initiative through its e-Book program.

The e-Book program in Malaysia began in 2009 with the distribution of e-Book to primary school children (aged 11-12). To date, more than 70,000 students have received e-Books involving huge sum of investments. The e-Book in Terengganu is a mini laptop that is installed with academic applications including text books, dictionary, *digital Quran* and daily *doa*. For the purpose of clarity, the term e-Book in this paper will refer to this description. The aim of this program is to support learning activities and to expose students to ICT. Although this effort is much applauded, it prompts the question of quality (of the software used in e-Book).

It is argued that in order to get the best outcome from e-Book and on-line learning, quality of the software should be of 'acceptable' standard. As such, a systematic approach should be used to evaluate the software quality in e-Book. Unfortunately, there has been limited attention given (if any) for this purpose despite the substantial investment involved.

Quality of any product is vital and affects end-user satisfaction [3, 4]. Comprehensive specification and evaluation are key factors in ensuring software quality. One approach to evaluate software quality is by defining an appropriate quality model and characteristics [5].

This paper proposes a software quality model based on the ISO 9216 for evaluating e-Book, identifying relevant quality characteristics and sub-characteristics. Although the ISO 9126 has not been applied extensively to the education domain, we believe that it has potential to be a useful tool for evaluating the software in e-Book.

This paper is organized as follow: background of the study and problem is amplified in Section 1. Section 2 presents a comparison of quality models found in literature. Section 3 proposes a software quality model for e-Book. Section 4 refines the model entailing quality sub-characteristics and evaluation criteria. Finally, conclusion and direction for further research are presented in Section 5.

2. Literature Review

This section presents several software quality models as the foundation for proposing an appropriate model for e-Book. A quality model is defined as '*the set of characteristics and the relationship between them, which provide the basis for specifying quality requirements and evaluating product quality*' [5]. There are numerous works found in literature focusing on software products evaluation such as [6-8]. Among the most accepted models include McCall, Boehm, FURPS, Dromey, Bayesian and ISO 9216.

2.1 McCall Model

McCall defines the quality of a software product through 3 different perspectives namely *Product Operations*, *Product Revisions* and *Product Transitions* [9]. It consists of 11 quality factors to describe the external view of the software (users' view); 23 quality criteria to describe the internal view of the software (developer's view); and a set of metrics that are used for quality evaluation. The fundamental idea of this model is assessing the relationship among external quality factors and product quality criteria. A major contribution of this model is the relationship between quality characteristics and metrics. However, there are criticisms such as not all metrics are objectives [5] and the functionality of software product is not considered in this model [10].

2.2 Boehm Model

Boehm introduced a model for evaluating the quality of software both automatically and quantitatively [11, 12]. It presents a hierarchical structure similar to McCall consisting of *High-Level*, *Intermediate-Level* and *Low-Level Characteristics*. Each of these characteristics contributes to the total quality of software product. This model takes into account some considerations of software product with respect to the utility of the program. Boehm also extended characteristics to the McCall model by emphasizing the *Maintainability* factor of a software product, which is one of the advantages of this model. However, it does not suggest any approach to measure its quality characteristics [5].

2.3 FURPS Model

Robert Grady and Hewlett Packard proposed the FURPS model that decomposes characteristics into 2 categories of requirement: *Functional Requirements* and *Non-Functional Requirements* [13]. Functional requirements (F) are defined by input and expected output while non-functional requirements (URPS) consist of usability, reliability, performance and supportability. It is important to note that domain specific attributes and software product portability were not addressed in this model.

2.4 Dromey Model

Dromey proposed a working framework for evaluating requirement determination, design and implementation phases [14, 15]. The framework consists of three models namely *Requirement Quality Model*, *Design Quality Model* and *Implementation Quality Model*. Layers are defined as high-level attributes and subordinate attributes. The main idea of this model is to create a framework that is broad enough for different systems; and to understand the relationship(s) between characteristics and sub-characteristics of quality product [10]. As such, different evaluation is proposed for each product. However, a more dynamic modeling of the process is needed since this model lacks the criteria for measuring software quality.

2.5 Bayesian Belief Network Model

The Bayesian Belief Network (BBN) model is represented in hierarchical structure, similar to McCall and Boehm. The structure is graphically illustrated, where nodes represent *Variables* and arrows represent the *Relationships* between nodes [16, 17]. The root of the tree represents the node quality and is connected to quality characteristics nodes. Each quality characteristics node is further connected to corresponding quality sub-characteristics. The advantage of this model is that it can represent and manipulate complex models that could not be implemented using conventional methods [10]. However, this model cannot be used for evaluating software quality product due to the lack of characteristics.

2.6 ISO 9126 Model

ISO 9126 is an international standard for the evaluation of software [18]. It is divided into 4 parts which addresses the *Quality Model*; *External Metrics*; *Internal Metrics*; and *Quality in Use Metrics*. This model is based on previous works by McCall, Boehm, FURPS, etc. The fundamental idea behind this model is specifying and evaluating the quality of a software product in terms of internal and external software qualities and their connection(s) to attributes. Quality attributes are classified into a hierarchical tree structure of characteristics and sub-characteristics. The highest level consists of quality characteristics and the lowest level consists of quality criteria. ISO 9126 specifies 6 characteristics that are further divided into 21 sub-characteristics. These sub-characteristics are manifested externally when the software is used as part of a computer system, and the results of internal attribute. The main advantage of this model is that the characteristics defined are applicable to every kind of software while providing consistent terminology for software product quality.

This section has presented several quality models for evaluating software product. Table I illustrates a comparison between the models including advantages and disadvantages. It can be concluded that the ISO 9126, since it is based on previous works and models, is more complete than the other (older) models and suitable to be used in the evaluation of e-Book. ISO 9126 covers all crucial characteristics such as hierarchical structure; criteria for evaluation; comprehensive expression and terms; simple and accurate definitions; and one to many relationships between various layers of model [10]. In addition, work in [19] also concluded that ISO 9126 supports strategic decision-making activities, avoiding costly mistakes.

Table 1. Comparison of Software Quality Models

CHARACTERISTICS MODEL	MCCALL	BOEHM	FURPS	DROMEY	BBN	ISO 9126
STRUCTURE	Hierarchical	Hierarchical	Hierarchical	Hierarchical	Non-Hierarchical	Hierarchical
NUMBER OF LEVELS	2	3	2	2	n/a	3
RELATIONSHIP	Many-Many	Many-Many	One-Many	One-Many	Many-Many	One-Many
MAIN ADVANTAGE	Evaluation Criteria	Hardware Factors Included	Separation of FR & NFR	Different Systems	Weighted Factors	Evaluation Criteria
MAIN DISADVANTAGE	Components Overlapping	Lack of Criteria	Portability not Considered	Comprehensiveness	Lack of Criteria	Generality

3. Software Quality Model

This section proposes a model for quality evaluation of software product in e-Book. Based on the discussions in the previous section, it is proposed that this model is based on the ISO 9126; or extending it to include newly identified quality characteristics. Software evaluation based on the ISO 9126 for the education domain is not a new approach and has been used before as reported in [7, 8, 10]. However, research efforts in adapting ISO 9126 for e-Book are limited (if any), leading to the novelty of this work. The main application of this work is in the education domain, and as such, the focus of software evaluation is e-Book in the education system.

The role of ICT in the academic domain specifically e-learning and courseware is still evolving [7, 8, 20]. It is interesting to note that although the ISO 9126 model does not prescribe specific quality requirements, it does however define a general framework for the evaluation of software quality. This is the main strength of this model as it can be used across many systems including the academic domain i.e. e-learning systems.

The ISO 9216 has been used to detect design flaws in e-learning systems [20]; to evaluate e-learning quality using generic external quality characteristics and sub-characteristics [8]; to evaluate Computer-Based Systems [7]; and to analyze technological, managerial and economic factors in e-learning systems [21]. The generality of the ISO 9126 means further analysis and mapping of characteristics is required before it can be fully adapted to e-Book. ISO 9126 specifies 6 characteristics namely *Functionality*, *Reliability*, *Usability*, *Efficiency*, *Maintainability* and *Portability* and 21 sub-characteristics. The quality characteristics are briefly discussed below:

3.1 Functionality

Functionality is ‘*the capability of the software to provide functions which meet the stated and implied needs of users under the specified conditions of usage*’. Functionality is divided into 5 sub-characteristics: Suitability, Accuracy, Interoperability, Security, and Functional Compliance.

3.2 Reliability

Reliability is *'the capability of the software product to maintain a specified level of performance when used under specified conditions'*. Reliability is divided into 4 sub-characteristics: Maturity, Fault Tolerance, Recoverability and Reliability Compliance.

3.3 Usability

Usability is *'the capability of the software product to be understood learned, used and attractive to the user, when used under specified conditions'*. Usability is divided into 5 sub-characteristics: Understandability, Learn-Ability, Operability, Attractiveness and Usability Compliance.

3.4 Efficiency

Efficiency is *'the capability of the software product to provide appropriate performance, relative to the amount of resources used, under stated conditions'*. Efficiency is divided into 3 sub-characteristics: Time Behavior, Resource Behavior and Efficiency Compliance.

3.5 Maintainability

Maintainability is *'the capability of the software product to be modified'*. Modifications include correction, improvements or adaptation to changes in the environment, in requirements; and functional specifications. Maintainability is divided into 5 sub-characteristics: Analyzability, Changeability, Stability, Testability and Maintainability Compliance.

3.6 Portability

Portability is *'the capability of the software product to be transferred from one environment to another'*. The environment includes organizational, hardware, and software. Reliability is divided into 4 sub-characteristics: Adaptability, Install-Ability, Co-Existence, Replace-Ability and Portability Compliance.

The generality of ISO 9126 makes it possible to classify quality characteristics according to domain [20]. This is due to the fact that none of the quality characteristics can be measured directly, but in fact, should be assessed in terms of the objective of sub-characteristics and criteria of the software [5]. Thus, the context of evaluation should be taken into consideration before determining on specific quality characteristics to be used [7]. This includes description of the software product and the environment the software will be deployed.

Quality characteristics based on the ISO 9126 that have a direct impact to e-Book can be classified into FIVE (5) namely Functionality, Reliability, Usability, Efficiency and Portability (Table II). Sub-characteristics are also identified and analysis of how these characteristics and sub-characteristics influence e-Book is also presented in the model.

Table 2. Software Quality Model For E-Book

CHARACTERISTICS	SUB CHARACTERISTICS	CONTEXT
FUNCTIONALITY	Suitability	Can the software perform the tasks assigned?
	Accurateness	Can the software produce expected results?
	Interoperability	Can the software interact with other software/ system?
	Security	Is the software equipped with acceptable security measure?
	Compliance	Does the software meet existing requirements?
RELIABILITY	Maturity	Can most of faults be eliminated over time?
	Fault Tolerance	Can the software handle errors?
	Recoverability	Can the software resume working and restore data?
	Compliance	Does the software meet existing reliability standards?
USABILITY	Understandability	Can the software be understood easily?
	Learnability	Can the software be learnt easily?
	Operability	Can the software be operated with minimal effort?
	Attractiveness	Does the interface of the software appealing?
	Compliance	Does the software meet existing usability standards?
EFFICIENCY	Time Behaviour	Does the software behave in a timely manner?
	Compliance	Does the software meet existing efficiency standards?
PORTABILITY	Adaptability	Can the software be adapted easily?
	Installability	Can software be installed easily?
	Coexistence	Can the software work with existing software/ system?
	Replaceability	Can the software be replaced with similar product?
	Compliance	Does the software meet existing portability standards?

Functionality is chosen as it is dependent on the application domain (education) while Reliability is chosen as it concerns information presentation and content in academic product [20]. Usability is included as it is an important factor especially in user driven applications [5]. Efficiency is also included as it refers to the capability of the software product to provide usable function to achieve its aim [20].

Maintainability is left out from the model since it can be only evaluated either by the developer or third party with access to the technical documentation of the project and the source code [22]. Although most software product perceives maintainability as an important quality characteristic, it is only evaluated in the early stages of development [22]. This is in line with software product evaluation in the academic domain, where Maintainability and Portability are not deemed important characteristics. However, it is argued that Portability should be included in the model as software product(s) needs to co-exist with existing ones.

4. Refinement of Characteristics

This section presents the refinement of the proposed model by incorporating quality criteria to be evaluated. These criteria are used to aid the evaluation of the software product from the user's perspective. There are five criteria that should be evaluated in e-Book (Table III):

- i. Functionality – Does the software product include academic-related functions?
- ii. Reliability – Is the software product reliable?
- iii. Usability - Is the software product easy to use by the target user?
- iv. Efficiency – Does the software product uses hardware/ software efficiently?
- v. Portability – Is the software product easy to transfer (one environment to another)?

Table 3. Quality Criteria and Characteristics for e-Book

CRITERIA	QUALITY CHARACTERISTICS	Functionality	Reliability	Usability	Efficiency	Portability
	Access Controllability	√				
	Clarity	√		√		
	Communication Commonality	√				
	Completeness Of Description			√		
	Consistency Of Layout			√		
	Content Quality	√				
	Demonstration Accessibility			√		
	Ease Of Installation					√
	Ease Of Understanding Information			√		
	Easy Of Performing Tasks			√		
	Effectiveness Of Design Content			√		
	Effectiveness Of Help System In Use			√		
	Effectiveness Of Navigations Tools Function			√		
	Effectiveness Of Search Engine Function			√		
	Effectiveness Of User Documentation			√		
	Effectiveness Of Visual Display			√		
	Error Messages		√			
	Failure Avoidance		√			
	Flexibility And Speed				√	
	Hardware Environmental Adaptability					√
	Hardware Independence					√
	Incorrect Operation Avoidance		√			
	Input And Output Devices Utilization				√	
	Load And Response Time				√	
	Mean Recovery Time		√			
	Network Reliability	√				
	Preventing Errors		√			
	Processing Time				√	
	Restart Ability		√			
	Restorability		√			
	Robustness		√			
	Simplicity			√		
	Software Independence					√
	Suitability Of Hardware Size, Weight, Battery Life			√		
	Uniformity	√		√		

This refinement is done in order to ensure a systematic approach for evaluating the quality more thoroughly i.e. for each quality characteristics identified.

5. Conclusion

This work has proposed a model for software product evaluation in e-Book based on the ISO 9126 standards. There are two immediate contributions of of this work: comparison and analysis of existing software quality models; and identification of quality characteristics for e-Book. Breakthroughs in ICT especially e-Book has effected education in a positive manner and there are few directions for future research in this field including development of tools for quality evaluation; application of the proposed model in other domains; and empirical assessment of user's satisfaction. It is hoped that this work will pave way to research in e-Book and other ICT-related product in education.

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