

# Modeling Measurement Metrics for E-Book App on Mobile Devices

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**Abstract**—Usability evaluation for mobile e-book applications is limited and did not address all the important metrics for usability measurements. Hence, this study aimed to identify the characteristics that affect user satisfaction on the usability of mobile e-book applications. Five characteristics that have a significant effect on the user satisfaction of mobile e-book applications have been identified namely readability, effectiveness, accessibility, efficiency, and navigation. A usability evaluation test was conducted on three mobile e-book applications namely Adobe Acrobat Reader, Ebook Reader, and Amazon Kindle. 30 students from Universiti Utara Malaysia evaluated the mobile e-book applications and their satisfaction was measured using questionnaire. The outcomes discovered that the five characteristics have a significant positive relationship with user satisfaction. This provides insights into the main characteristics that increase user satisfaction

**Index Terms**—E-Book Applications, Usability Evaluation, User Satisfaction.

## I. INTRODUCTION

The letter E in the Electronic book is a novel word in the arena of publication [1]. In the world of literature, e-book is one of the most considerable development since Gutenberg press [2], and is intended to transform the reading routines of many in the upcoming years [3]. Nowadays, reading e-books is becoming popular and influenced by the increasing number of adults who own e-readers devices or tablets [4]. In U.S. the increase in reading e-book among adults had been increased from 17% in 2011 to 28% in 2016 [5]. Mobile devices' usefulness has been increased greatly in latest years [6], and mobile users are progressively more dependent on their communication and their lifestyle on mobile phones [7]. Subsequently, the mobile phone became another essential reading platform [8]. Currently, an extensive reading is done online in different screen sizes by using a variety of e-book applications. However, conventional books are slowly replaced by these devices and applications [9]. On the other hand, e-books still has some significant usability issues [10]. This has been shown to be true for a variety of devices for textbook access, including the iPod Touch and cell phone [9].

Usability is a critical point to success or failure for any device, system, and application [11]. Users these days are actively looking for convenient, easy to use applications in terms of learning and completing a particular task [12]. Mobile devices and their applications have different usability issues when accessed through different computer systems due to different characteristics such as small screen sizes, different display resolution, connectivity issues, and limited data entry models [12].

Literature has indicated a good number of studies on the usage of e-book throughout the literature for both, education and leisure purposes [13–16]. In spite of the advantages of the e-book, many usability issues regarding the design of the interface have also been reported.

Usability of an interface in an e-book application and its features can have a significant impact on readers' interaction with the reading content [17]. Accordingly, it is essential for user satisfaction in reading e-books to create an interface that offers simple and prompt access [18]. According to [19], the readers have been disadvantaged by reduced legibility or interface issues while reading an e-book on the screen. In parallel, study conducted by [20] reported that lack of supporting the text-to-speech feature by some platforms is an essential consideration as it can potentially support reading by users with vision disabilities.

Despite the fact that there are some proposals to standardize the e-book interface designs, adherence to these guidelines does not appear [9, 21]. Similarly, prior evaluation models are only focused on evaluating one or two aspects of usability such as the readability and navigation and accessibility of these applications. Though, previous studies have also reported some other important characteristics that increase the usability such as readability [9, 20, 22, 23], effectiveness [22, 23]; yet still; there is a lack of empirical evidence pertaining to their relationship and significance. Henceforth, keeping the paucity of research and importance of the issue beforehand, the current study aimed to propose a model for evaluating the usability of mobile e-book applications.

## II. LITERATURE REVIEW

Evaluation plays a significant role in software development. It is aimed to determine as to whether or not; the user requirements are met. In addition, it is also essential to help assess system's relevance for one task or a set of tasks and help to compare with other similar products in the market [24].

Usability is a central concept in software evaluation. It is comprehended as a quality characteristic that assesses the ease of using an application. It also assesses the methods that have been used to enhance ease of usage through the design process [7, 25]. Usability is one of the quality aspects that have been facing challenges in mobile devices due to the portability of the devices [6, 26].

### A. E-Book Background

Michael S. Hart, a student at the University of Illinois, in the 1970s, launched the Gutenberg Project, archiving digitized versions of cultural documents. This was the earliest

concepts concerning to general e-books [27]. The idea of reading a book through using electronic devices is not new as it has existed since interaction began between end-users and computing devices [2]. Literature defines e-books in several ways whereby, majority of these definitions reflect upon the development over time in e-book. Fundamentally, an electronic book is just a series of bits; 1s and 0s which collectively create a readable script in the shape of a book [28]. Nowadays, e-books also come in complex formats and can be aided with additional multimedia devices. Additionally, they can also be added linked with social media platforms like Facebook and Twitter [29].

During the late 1960s, the earliest devices for e-reading were designed by Alan Kay who later on brought some other generations of devices also. These developments have resulted in increase in the mobile device usage in relation to e-book applications over the years. Moreover, several supporting features have also been developed these days such as bookmarks, highlighting, the ability to make a handwritten note, and the ability to share over the social networks [9]. The user interfaces of these applications vary from one another yet, the content is mainly similar. These applications require prospective users to learn how to interact with every interface each time they use new applications [9]. Sadly, majority of these devices seem to have been developed with innovation and precession but with very little consideration for user needs [2]. Despite the fact that there are some proposals to standardize these interfaces design but the adherence to these guidelines seems absent. Moreover, the guidelines forwarded by [30] nearly ten years ago were largely based on the evaluation of web e-books and outdated e-book readers [9], [21].

#### *B. Usability Evaluation Models for Mobile E-Book*

Addressing usability for the e-book is necessary in order to design interactive systems by considering the user needs [14]. Studies like [31, 32] have examined the effects of using e-books in education. Despite the advantages of e-book, students find it harder to read on a computer/tablet screen and even harder to get an overview of the content compared to paper books. Another study by [33] deployed UTAUT to examine the influence factors that hinder fast development of e-books and ways to enhance the practical service of this novel product. Their findings outlined great promotion in the development of e-books in mobile marketing can be achieved with high-quality content, media promotion, and user-friendly interface.

In [30], the guidelines for designing an electronic book were been defined. Two essential styles have emerged as standard towards e-book ease of use. Moreover, the paper book inheritance metaphor and user associating with new medium has brought another collection of requirements. These sorts of themes, together with facets of hardware design and style, were investigated through the EBONI Project in some e-book evaluations whereby, the results establish an assortment of electronic textbook design guidelines.

For the purpose of setting up design guidelines for e-readers, [22] conducted study to examine the usability problems of the interface of the e-readers using HCI principles. The research was carried out using three e-readers. This study evaluated the readers devices based on HCI guidelines which are metaphor, light-weight, ergonomics, completeness, and active reading functions. Accordingly,

completion and Active reading function such as bookmarking, annotation, page turning, and magnification were used to evaluate the software usability. The study outlined that the three e-readers put down a lot to be preferred from HCI perspective and usability point of view.

Moving further, [2] attempted to study five e-readers to outline their legibility and usability by using the ISO 9241-11 model. In order to evaluate the usability, participants were asked to perform five tasks. Upon the evaluation of these e-book readers in term of design, navigation, orientation, functionality, and handiness; the users experienced dissatisfaction. This dissatisfaction was mainly caused due to the interaction with the number of the e-readers which damaged their post-judgment and satisfaction. This study highlighted that changing font size is essential feature to increase the accessibility, especially for older people and the ones with vision issues. The results of this study also showed a notable insufficiency in the usability of the current e-reader generation.

In parallel, [23] studied the usability and satisfaction from a user perspective of five e-reading applications. Therein, Barnes & Noble's Nook BNRV100; the Amazon Kindle; the Apple iPad MB292LL/A; Sony Digital Reader PRs-950; and Borders' kobo reader N647-BUS-S were taken into consideration. The study relied on the survey involving 81 graduate students who owned an e-reader. The participants were asked to outline their individual issues, and what they liked and/or disliked. In addition, the respondents were also requested to volunteer for an ethnographic journaling research which permitted eight users to reside with each one of the selected five readers for at least two days. In this study, usability was measured based on how convenient the app makes it to perform tasks; the ability to share titles and the availability of dictionary.

Another study by [34] studied the usability of three touch-screen e-readers (iPad, Nook tablet, and Kindle Fire) for essential book navigation tasks. Participants rated all devices based on their observation of workload and satisfaction. Outcomes revealed that there were no considerable differences relating to the devices in relation to satisfaction and workload. Conclusively, the study reported that in general, participants were not satisfied with these devices.

Since there are many universities and schools planning to start offering e-textbooks in place of conventional paper textbooks, [13] strived to study the usability, engagements, and satisfaction of two text-books applications, Kindle and Inkling. The purpose of this study was to test the usability of these applications in term of how convenient are they in making notes and bookmarks, highlighting, navigating, change of text size, deleting of bookmarks and notes, and search of a text. Both applications were tested using an iPad. Overall findings of the study show that participants were satisfied with e-textbooks for a study purpose, and there was no significant difference between the two applications in term of satisfaction, perceived workload, and comprehension.

In [9], the study investigated the usability of eight e-textbooks reading applications. They intended to compare and contrast the features offered by each of the eight applications with the focus on how these features are implemented and evaluate the usability based on error investigation point of view. Those eight e-textbooks were Chegg, ibook, VitalSource, Kno, Inkling, Nook, and Kindle. Their study reported that current e-textbooks application have a variety of user interfaces which suggests that there is no

standardization in term of interface design. As a result, student may end up wasting their time in learning new interfaces every time they use a new application. In addition, it will also lead towards causing interruption in study of the course material. This study examined four main features of e-book. These features are bookmarking, note taking, search by word, and locate note book.

Another study by [20] can be found which attempted to evaluate the academic e-books from the user perspectives. The study examined sixteen e-book platforms used in academia. They investigated the usability features provided by these platforms and the accessibility from a student perspective, and practically for those with a disability. The main usability features reported were the tables of content; the ability to change font size and zooming; movement to specific page number; ease in taking notes; the ability to print, and options to download titles offline. Accessibility for these platforms in term of providing text-to-speech feature is essential for supporting reading with visual disabilities. Lack of providing text-to-speech had been reported by almost all platforms that users need to download other application to access materials while some platforms do not support at all.

### III. METHODOLOGY

Base on the primary objective of this study which was to design a usability evaluation model for mobile e-book application; this study devised four steps to achieve this goal. The first step related to identify the requirements for developing the model which was the main characteristics and the associated metrics. Second step concerned with the development for creation of usability evaluation of model for mobile e-book application based on the user satisfaction. Therein, questionnaire was designed to measure the user satisfaction. Thirdly, the study was formulated to test the hypotheses. Finally, the evaluation phase was established to validate the proposed model by implementing a usability test followed by the satisfaction questionnaire.

This study reviews the literature and comes with the following characteristics for evaluating the usability of the e-book application:

1. **Readability:** as defined by [35], readability is “the ease with which visual content can be understood”. Readability is significant as a first-rate sign of comprehension which is a main element in the reading environment of the user experience [36].
2. **Effectiveness:** Effectiveness is the ability in which the users can accomplish tasks by using the system, and the quality that can come from the outputs after accomplishing those tasks [6].
3. **Accessibility:** the ability to use the system by users with some sort of disability like visual, psychomotor, and hearing disability [37].
4. **Efficiency:** according to ISO 9241-11 Efficiency is about how much resources spent in relation to the completeness and accurateness with which users reach targets [38].
5. **Navigation:** people need to know what is within their environment (physical world, electronic world, or Virtual). Good information and program design might provide such support and provide new means of navigating [39].

This study assumed that these characteristics have a significant effect on the user satisfaction of the mobile e-book

applications. Therefore, the study has five hypotheses. Figure 1 depicts the proposed model.

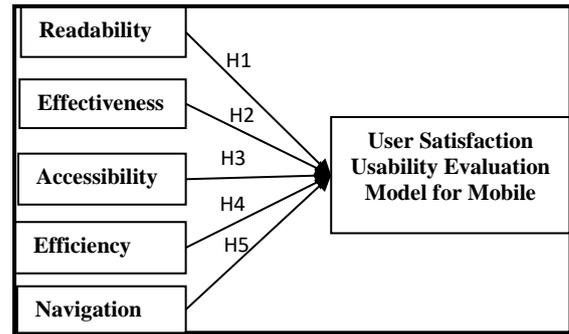


Figure 1: Usability evaluation model for mobile e-book application

Questionnaire is one from the effective techniques used to gather the data [40]. This present study deployed interviewer-administrated questionnaire technique to ensure that the participants test the application before giving their responses to the questions which will also help improve the reliability of the data.

Thirty participants (17 males and 13 females) from Universiti Utara Malaysia evaluated the proposed model. The age of the participants ranged from 21 to 40 years. Majority of the participants were students, enrolled in doctoral programs (53.33%). Accordingly, half of the participants reported having more than three years experiences in mobile E-book applications and only four participants reported no experience in this regard. Three e-book applications were used in the test namely: Adobe Acrobat Reader, Ebook Reader, and Amazon Kindle. In parallel, every ten participants were also taken to evaluate one of these applications by using one Smartphone device with 5.5-inch screen size. The time taken to complete all the tasks was recorded by using a stop watch app.

### IV. RESULTS

In this study, the data collected was quantitative in nature, coming from the usability test and the questionnaires. This data was analyzed through using SPSS (version 23). These data was subjected to test the hypotheses and validate the model and compare the satisfaction between the different applications used in the test. Furthermore, some patterns of the satisfaction could also be discovered within the different types of users and different user mobile experiences. Several statistical methods were used to assess the data, including descriptive analysis, correlations, and multiple regressions.

#### A. Hypotheses Analysis

Pearson's correlation was run to determine the relationship between the five characteristics and user satisfaction. The results show that all the hypotheses were supported. This suggests that all the proposed five characteristics were significantly influencing satisfaction of the e-book users (there is a positive relationship between each characteristic and the user satisfaction). Table 1 presents the results from the correlation analysis.

Table 1  
Summary of the results for hypothesis testing

Hypothesise	r	p-value	Decision
H1	.595	.001	All supported
H2	.637	.000	
H3	.521	.003	
H4	.523	.003	
H5	.544	.002	

### B. Multiple Regression Analysis

Standard multiple regressions are used to check the model fit. The finding shows that F value is statistically significant (F=22.015, P<0.05), which indicates that the model is statistically significant [41]. The R<sup>2</sup> for this model turned out to be 0.821 whereby, adjusted R<sup>2</sup> resulted to be 0.784. This asserts that independent variables explained 78.4% of variance in the dependent variable. The results from the multiple regressions also show which independent variable is significantly contributing to the satisfaction level. These results are presenting in Table 2.

Table 2  
Regression analysis results

Model	Unstandardized Coefficients (B)	t	Sig.
(Constant)	-.361	-.896	.379
Readability	.121	1.565	.131
Effectiveness	.253	2.498	.020
Accessibility	.225	4.950	.000
Efficiency	.165	1.837	.079
Navigation	.316	3.633	.001

As shown in Table 2, the independent variables (Readability, Effectiveness, Accessibility, Efficiency, and Navigation) contributed significantly towards explaining the dependent variable (Satisfaction). The highest contribution resulted from Navigation variable (B=0.316, t=3.633, Sig=0.001); explaining 31.6% of statistical significant influence (while holding other predictors in the model constant). Following this, Effectiveness marked the major influence on e-book user satisfaction (B=0.253, t=2.498, Sig=0.020); explaining 25.3% statistical significant influence. Similarly, Accessibility (B=.225, t=4.950, Sig=.000) explaining 22.5% statistical significant influence. Efficiency and Readability marked the lowest contribution in explaining the dependent variable whereby Efficiency (B=0.165, t=1.837, Sig=0.079), explaining 16.5%, and Readability (B=0.121, t=0.1.565, Sig=0.131), explaining 12.1% respectively.

In general, multiple regression procedures will estimate a linear equation of the form:

$$Y = A + b_1 * X_1 + b_2 * X_2 + \dots + b_p * X_p$$

whereby, Y is the response or the dependent variable; A is Y-intercept; Y-intercept is the value of the Y variable when Xs = 0, and the predictors X1... Xp, the regression coefficients b1... bp. The regression coefficients (or B coefficients) represent the independent contributions of each independent variable towards the prediction of dependent variable. According to the results shown in Table 2, the contribution of the independent variables (X1=Readability, X2=Effectiveness, X3=Accessibility, X4=Efficiency,

X5=Navigation) explains the dependent variable is as following:

$$Y = 0.361 + 0.121X_1 + 0.253X_2 + 0.225X_3 + 0.165X_4 + 0.316X_5 = 0.719.$$

As a result, the proposed model explained 71.9% variance for user satisfaction level relating to the usability of e-book application, which indicates a good fit of the proposed model.

### V. CONCLUSION

This study identified five characteristics to evaluate the usability of mobile e-book applications, namely: Readability, Effectiveness, Accessibility, Efficiency, and Navigation. The results have outlined that the five characteristics proposed in the study have a significant relationship with the user satisfaction. However, three of these characteristics namely Navigation, Effectiveness, and Accessibility proved to be more significantly related to e-book user. The proposed model has resulted to be significantly fit whereby; the independent variables explained 78.4% variance towards the dependent variable. The proposed model explained 71.9% variance for user satisfaction level relating to the usability of e-book application. This study has some limitations with regards to the number of applications it examined and the type of the users it considered to be part of the study (only academic students from Universiti Utara Malaysia) which may restrict the validity and generalizability of the findings.

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