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Full Length Article

# Empirical investigation to explore factors that achieve high quality of mobile learning system based on students' perspectives

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ABSTRACT

This study presents three frameworks for mobile learning system based on quality factors derived from the updated DeLone and McLean information system success model. This study used the questionnaire as a quantitative method to explore quality factors for mobile learning system based on perspectives of 392 students. This study opens future work for using the identified quality factors as guidelines for researchers and designers to design and develop mobile learning applications.



## 1. Introduction

In the recent years, the great development of mobile technologies has generated a new way for learning in university environments called mobile learning (m-learning). Mobile learning is now the newest technology to achieve optimum learning advantages [1], by providing the opportunity for teachers as well as learners to access educational materials and services through mobile devices at any time and any place. The new and advanced features in smart phones such as streaming video, color display screen, and internet browser makes mobile learning not only possible but also practical. Furthermore, many researchers presented strong arguments for the benefits of mobile learning such as mobility, freedom and self study, facilitation of student–teacher communication and interaction and information sharing [15,20]. Since then, the interest in the development and use of mobile learning system in the university environment has been continuously increasing [14]. However, mobile learning is still in the beginning stage of implementation in the university environment [5,17]. To implement the mobile learning system successfully, the universities are responsible for understanding how to best exploit themobile learning system for learning purposes and to know what services should be offered by the mobile learning system for students. In order to understand how to best exploit and use the mobile learning system for learning in student universities, the first step is to understand the students' perspectives and perceptions of the mobile learning system. Additionally, students do not want just mobile devices; they want a high quality of mobile learning system which satisfies and meets their needs and requirements in order to accept and use this technology. Students' perspectives and perceptions of quality factors for mobile learning systems could provide information needed for universities and designers to make better decisions regarding mobile learning implementation. Therefore, this study contributes to the literature through achieving two objectives:

1. To present three proposed frameworks for the mobile learning system based on quality factors.
2. To analyze and evaluate the factors that achieve high quality of the mobile learning system based on students' perspectives and perceptions.

The structure of this paper is organized as follows: Section 2 summarizes the previous studies and frameworks that developed for mobile learning system components. Section 3 presents the contribution of the study to the literature in the area of mobile learning. Section 4 describes the theoretical background. The three proposed frameworks are presented in Section 5. Sections 6 and 7 present the methodology of research and data analysis. Finally, Section 8 summarizes this paper and future works.

## 2. Related works

There are several frameworks that have been developed for determining the components of the mobile learning system. A recent study by Ng and Nicholas [16] suggested a framework for

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**Table 1**
Comparison between previous studies and frameworks for mobile learning system components.

| Literature | Frameworks/studies | Components/factors |
|---|---|---|
| Ng and Nicholas [16] | A framework for sustainable mobile learning | Economic sustainability<br>Social sustainability<br>Political sustainability<br>Technological sustainability<br>Pedagogical sustainability |
| Koole [11] | The framework for the rational analysis of mobile education (FRAME) model: an evaluation of mobile devices for distance education | Device usability<br>Learner<br>Social aspects |
| Motiwalla [15] | Mobile learning: a framework and evaluation | E-learning characteristics<br>Mobile connectivity |
| Liu et al. [14] | Factors driving the adoption of m-learning: an empirical study | Self efficacy<br>Learning autonomy<br>Teacher readiness<br>Student readiness<br>Subjective norm<br>Behavioral control |

sustainable mobile learning based on five components: economic sustainability, social sustainability, political sustainability, and technological sustainability, pedagogical sustainability. Koole [11] in his study focused on three criteria: device usability, learner, and social aspects to describe mobile learning in higher education. Another study entitled mobile learning: a framework and evaluation focused on extension of e-learning characteristics and mobile connectivity to propose a framework for mobile learning applications [15]. A study was conducted by Liu et al. [14] to explore what are the factors that influence the acceptance of mobile learning in China. The researchers proposed a model based on six factors: self efficacy, learning autonomy, teacher readiness, student readiness, subjective norm, and behavioral control. Based on the previous studies and frameworks above, these studies and frameworks ignored the quality factors as components in phases of design and development for mobile learning system implementation. Table 1 shows the comparison between previous studies and frameworks of mobile learning system components.

## 3. The proposed contribution of research

Based on Table 1 which presents the comparison between different studies and frameworks for mobile learning components, the researcher found that these frameworks were incomplete and do not cover all components. These frameworks ignored some components that could contribute to enhance the system quality, design and implementation, and how these components could be used as guidelines to develop high quality mobile learning systems that meet students' requirements. These studies ignored the quality factors that may contribute to a successful implementation of mobile learning systems. Based on these facts, this study proposes three frameworks for mobile learning systems based on three types of quality factors and eleven sub-quality factors:

1. Information quality (content usefulness, and content adequacy).
2. System quality (functionality, accessibility, interactivity, interface design, and ease of use).
3. Service quality (availability, personalization, trust and responsiveness).

## 4. Theoretical background

### *4.1. The updated DeLone and McLean information system success model (DL&ML)*

A successful implementation of new systems and technology has become an important issue as reported in information system (IS) research. Many scholars had earlier made great efforts to identify the IS success factors. For this purpose, there are several models used to identify the success factors of the information system [19]. One of these models is known as the updated DeLone and McLean IS success model (DL&ML), as was described in detail in chapter two. Many researchers have found that the DL&ML is the robust model for measuring the IS success [18]. In addition, DL&ML is the most appropriate model to study the success of IS. It is considered as a powerful model for measuring the success factors of IS [8]. Over the researches, DL&ML model has been applied in a number of information systems such as e-government system [21], e-learning system [13] and m-banking [12]. The main idea of DL&ML model is to provide an extensive review for formulating the measures of information system success. The DL&ML model consists of three types of quality factors of information system which are: service quality, information quality and system quality [8]. These quality factors may be considered as the critical aspects of information system success. Also, many researchers noted that factors relating to quality played a vital role in the success of many types of information systems [2,4]. Therefore, the quality factors from DL&ML model are used as a foundation for constructing the three proposed frameworks for this study, which will be presented in the following section.

## 5. The three proposed research frameworks

This study provides three proposed frameworks based on quality factors for mobile learning systems. These frameworks are focused on different components and criteria such as system quality, information and services. The next sections will present the detailed description for the three frameworks.

### *5.1. Mobile learning system quality framework*

System quality depends on the quality of measures which are determined during the phases of system analysis, design and development in creating a worthwhile system. Practically, system quality depends on the users' perceptions, and thereby high levels of system quality may generate easy to use, comfortable, and effective of mobile learning applications. The system quality divided into five sub-criteria is functionality, accessibility, interactivity, ease of use and interface design [7]. Also, each of these sub-criteria is also divided into a number of sub-sub criteria as shown in Fig. 1. Therefore, system quality measures are included in the framework of this study which may be used to develop high quality mobile learning systems.

### *5.2. Mobile learning information quality framework*

Information quality refers to the quality and accuracy of content which is provided by the information system [7]. In the mobile learning context, information quality refers to the learning content such as lectures, courses, assignments, images and quizzes. The learning content is the primary component that plays a central role in the success of mobile learning applications because it

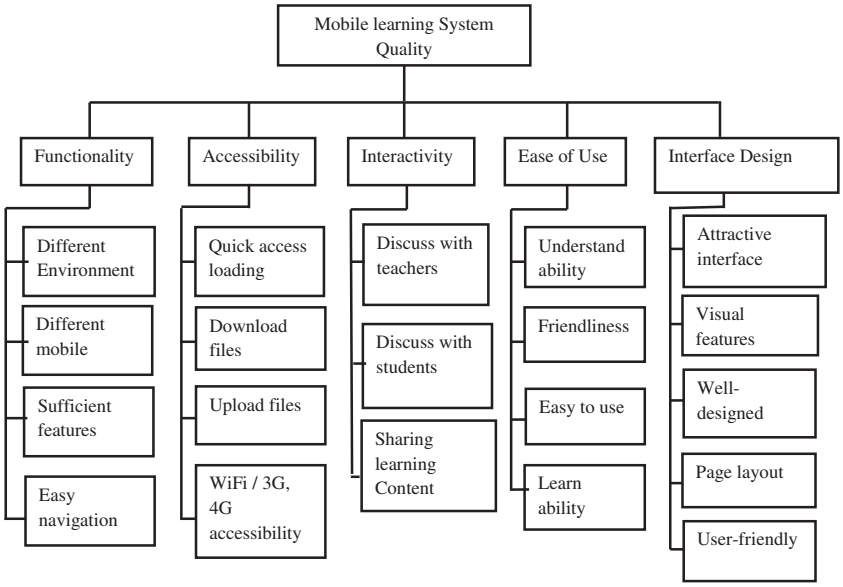


**Fig. 1.** The components of the mobile learning system quality framework.

contributes to fully engage of students in the learning experience. Another important point, information quality also refers to the learning content styles and formats such basic learning contents (text, graphics and charts), multimedia learning contents (audio, video and animation) and collaborative learning contents (share and send learning content files). Practically, information quality depends on the users' perceptions, and thereby, mobile learning application must be able to support the students' preferences of learning contents and formats. The information quality divided into two sub-criteria is content usefulness and content adequacy [10]. Also, each of these sub-criteria is also divided into a number of sub-sub criteria as shown in Fig. 2. Therefore, information quality measures are included in the framework of this study which may be used to develop high quality mobile learning systems.

### 5.3. Mobile learning service quality framework

Service quality definition depends on identifying users' requirement and how to meet them [10]. Service quality is the primary element that plays a central role in the success of any information system [10]. In the mobile learning context, students have individual requirements and they expect to be fulfilled through mobile learning application provided by the university. Thereby, service quality may contribute a vital role in the success of mobile learning applications in university environment. The service quality divided into four sub-criteria consists of availability, personalization, responsiveness and trust [10]. Also, each of these sub-criteria is also divided into a number of sub-sub criteria as shown in Fig. 3. Therefore, service quality measures are included in the framework of this study which may be used to develop high quality mobile learning systems.

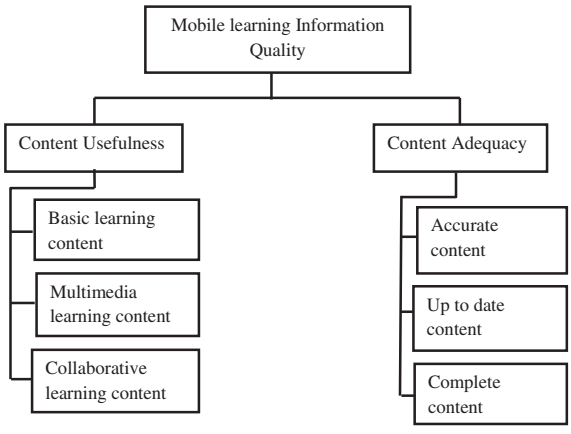


**Fig. 2.** The components of the mobile learning information quality framework.

## 6. Research methodology

This study used the questionnaire as a quantitative method to explore quality factors for mobile learning systems based on students' perspectives. The questionnaire instrument was derived from previous literature and different areas of information system (IS) research. The original questionnaire covered students' demographic information and included forty-three items for eleven factors proposed in the three frameworks, as presented in Appendix A. The items ranged from strongly disagree to strongly agree. Data were collected from a total of 392 students from five Jordanian public universities (Yarmouk University, University of Science and Technology, University of Jordan, Hashemite University, and Mutah University). The students who volunteered to fill in the questionnaire were from various specializations. Before the students begin in filling the questionnaire, the researcher summarized the objectives of this study and the definition of mobile learning; then the students answered on the questionnaire. Table 2 presents the frequencies among the participants with regard to their age, gender, study level, years of using mobile devices, and prior mobile learning experience.

## 7. Data analysis and results

In this study, the data analysis was performed using descriptive analysis, reliability and validity analysis, and exploratory factor analysis for testing and exploring the quality factors based on students' perceptions using SPSS 18.

### 7.1. Descriptive analysis

Descriptive statistics analysis was conducted for all items for their mean, standard deviation, and skewness and kurtosis for

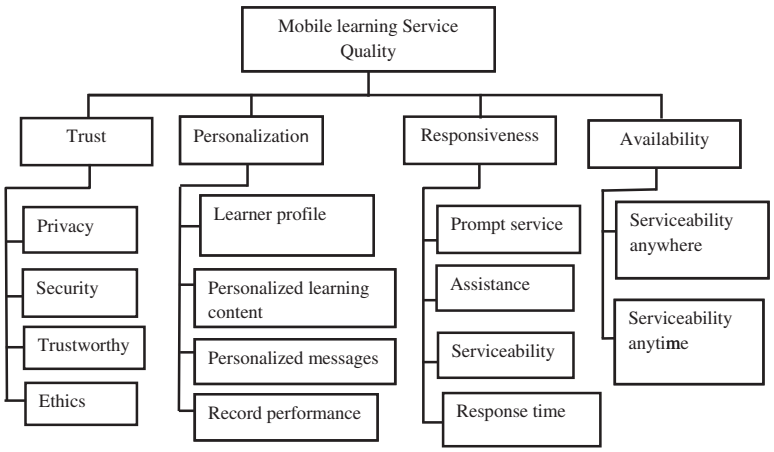


**Fig. 3.** The components of the mobile learning service quality framework.

**Table 2**
Characteristics of participants.

| Characteristics | Frequency | Percent |
|---|---|---|
| *Student age* | | |
| 18–20 | 114 | 29.1 |
| 21–24 | 200 | 51.0 |
| Over 24 | 78 | 19.9 |
| *Student gender* | | |
| Male | 185 | 47.2 |
| Female | 207 | 52.8 |
| *Study level* | | |
| Undergraduate | 261 | 66.6 |
| Postgraduate | 131 | 33.4 |
| *Years of using mobile devices* | | |
| Less than 1 year | 3 | 0.8 |
| 1–3 years | 56 | 14.3 |
| 3–5 years | 333 | 84.9 |
| *Mobile learning experience* | | |
| Yes | 345 | 88.0 |
| No | 47 | 12.0 |

testing normality of data. Skewness is a measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. Kurtosis is a measure of the "tailedness" of the probability distribution of a real-valued random variable. In a similar way to the concept of skewness, kurtosis is a descriptor of the shape of a probability distribution and, just as for skewness, there are different ways of quantifying it for a theoretical distribution and corresponding ways of estimating it from a sample from a population. The results showed that the values of mean ranged from (3.94) to (4.19) on a five point scale, which indicated that the most of students had satisfaction with the items of quality factors for mobile learning systems as shown in Fig. 4.

In addition, as results of the descriptive statistics are shown in Table 3, where the standard deviations ranged from (.093) to (1.04) which indicated that the values were acceptable, and the normality distribution of the data was sufficient because the values ranged between −1 and +1 according to skewness and kurtosis assumption.

### 7.2. Measurement models

To assess the measurement of three models, exploratory factor analysis (EFA) was employed in terms of factor loading, reliability of items, convergent validity and discriminant validity. EFA is a technique used to extract which of the items are most appropriate in each construct. The exploratory factor analysis was performed in this study on 43 items that measure quality factors: system quality (functionality, accessibility, interactivity, interface design, and ease of use) information quality (content usefulness, and content adequacy) and service quality (availability, personalization, trust, and responsiveness) that may be antecedents to develop high quality mobile learning systems. Table 4 provides a summary of results of the Cronbach's alpha (α) for reliability, values of factor loading for items. For reliability that tests the internal consistency among items in the same construct by using the Cronbach's alpha coefficient (α). The values of Cronbach's alpha (α) should be above 0.7 to be acceptable as suggested by [9]. As shown in Table 4, the

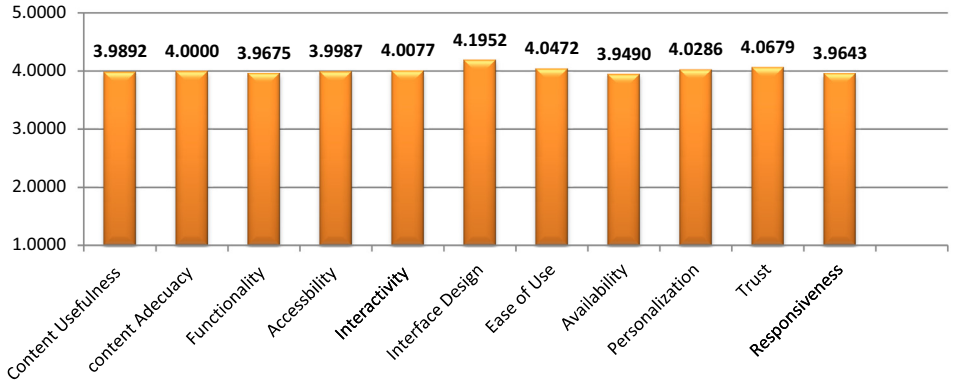


**Fig. 4.** Mean values of quality factors.

**Table 3**
Descriptive analysis.

| Factors | Items | Mean | Std. deviation | Skewness | Kurtosis |
|---|---|---|---|---|---|
| Content usefulness (CU) | CU1 | 3.9923 | 1.00761 | −.799- | .113 |
| | CU2 | 3.9872 | 1.00502 | −.795- | .104 |
| | CU3 | 3.9872 | .99479 | −.789- | .066 |
| | CU4 | 3.9898 | .99610 | −.791- | .070 |
| Content adequacy (CA) | CA1 | 4.0255 | .99326 | −.964- | .408 |
| | CA2 | 4.0000 | .98063 | −.949- | .459 |
| | CA3 | 3.9847 | .97265 | −.925- | .462 |
| | CA4 | 3.9898 | .98058 | −.912- | .387 |
| Functionality (F) | F1 | 3.9745 | 1.04593 | −.852- | .031 |
| | F2 | 3.9719 | 1.04464 | −.850- | .036 |
| | F3 | 3.9643 | 1.02837 | −.850- | .124 |
| | F4 | 3.9694 | 1.03102 | −.853- | .114 |
| Accessibility (AC) | AC1 | 4.0128 | .98963 | −.837- | .038 |
| | AC2 | 3.9923 | .99227 | −.853- | .135 |
| | AC3 | 3.9949 | .96484 | −.814- | .136 |
| | AC4 | 3.9949 | .97013 | −.851- | .254 |
| Interactivity (IN) | IN1 | 4.0153 | 1.00626 | −.924- | .254 |
| | IN2 | 4.0128 | 1.00502 | −.922- | .259 |
| | IN3 | 3.9974 | .99744 | −.912- | .287 |
| | IN4 | 4.0051 | 1.00126 | −.917- | .272 |
| Interface design (ID) | ID1 | 4.2270 | .96855 | −1.368- | 1.520 |
| | ID2 | 4.2015 | .96628 | −1.319- | 1.423 |
| | ID3 | 4.1837 | .97903 | −1.345- | 1.490 |
| | ID4 | 4.1684 | .97131 | −1.319- | 1.487 |
| Ease of use (EU) | EU1 | 4.0714 | .94612 | −.963- | .516 |
| | EU2 | 4.0663 | .94379 | −.958- | .525 |
| | EU3 | 4.0306 | .93747 | −.903- | .465 |
| Availability (AV) | AV1 | 4.0204 | .95398 | −1.000- | .736 |
| | AV2 | 3.9796 | .94590 | −.962- | .634 |
| Personalization (P) | P1 | 3.9796 | .94590 | −.962- | .634 |
| | P2 | 4.0204 | .98302 | −.983- | .578 |
| | P3 | 4.0255 | .98290 | −.993- | .600 |
| | P4 | 4.0230 | .96591 | −.919- | .406 |
| | P5 | 4.0255 | .96717 | −.921- | .401 |
| | P6 | 4.0485 | .94623 | −.989- | .674 |
| Responsiveness (R) | R1 | 4.0791 | .94144 | −.972- | .480 |
| | R2 | 4.0765 | .94029 | −.951- | .439 |
| | R3 | 4.0510 | .93931 | −.921- | .397 |
| Trust (T) | T1 | 4.0612 | .94142 | −.936- | .411 |
| | T2 | 4.0714 | .93524 | −.954- | .481 |
| | T3 | 3.9770 | .94719 | −.843- | .462 |
| | T4 | 3.9566 | .96785 | −.917- | .691 |
| | T5 | 3.9592 | .95332 | −.862- | .540 |

Cronbach's alpha was greater than 0.7, thereby indicating satisfactory reliability for all eleven latent constructs. For EFA the principal components analysis with Varimax rotation was conducted to determine the underlying structure for each factor in the research frameworks [3]. The principal components analysis depends on the values of factor loadings. According to Campbell and Fiske [3], the factor loadings should be greater than 0.7 for each item, and if the item has loadings less than 0.7 should be removed from the structure of the construct. The results in Table 4 showed that one item (P6) was removed from personalization factor due to the value of factor loadings less than 0.7. The other items were loaded on the appropriate factor with loadings of above 0.7. Therefore, eleven factors were discovered. Then Convergent validity was evaluated that measures whether items under individual scale are correlated; it can be evidenced by relatively high correlations between items under the same construct [6]. Convergent validity can be evaluated based on the factor loadings that should be greater than 0.7 as recommended by [3]. As presented in Table 4, the results indicated that the items loadings were above 0.7; thereby, the convergent validity for the proposed constructs is adequate.

**Table 4**
Results for the measurement of the three frameworks.

| Factors | Items | Cronbach's alpha ($\alpha \geqslant 0.70$) | Factor loadings (>0.7) | Items removed |
|---|---|---|---|---|
| Content usefulness (CU) | CU4 | 0.968 | .828 | No items |
| | CU3 | | .825 | |
| | CU2 | | .808 | |
| | CU1 | | .801 | |
| Content adequacy (CA) | CA2 | 0.938 | .870 | No items |
| | CA4 | | .869 | |
| | CA1 | | .865 | |
| | CA3 | | .862 | |
| Functionality (F) | F4 | 0.859 | .884 | No items |
| | F3 | | .878 | |
| | F2 | | .867 | |
| | F1 | | .866 | |
| Accessibility (AC) | AC3 | 0.860 | .857 | No items |
| | AC1 | | .856 | |
| | AC4 | | .855 | |
| | AC2 | | .841 | |
| Interactivity (IN) | IN4 | 0.922 | .880 | No items |
| | IN3 | | .880 | |
| | IN2 | | .870 | |
| | IN1 | | .857 | |
| Interface design (ID) | ID2 | 0.867 | .903 | No items |
| | ID1 | | .899 | |
| | ID3 | | .896 | |
| | ID4 | | .880 | |
| Ease of use (EU) | EU2 | 0.887 | .787 | No items |
| | EU3 | | .786 | |
| | EU1 | | .773 | |
| Availability (AV) | AV2 | 0.774 | .902 | No items |
| | AV1 | | .901 | |
| Personalization (P) | P1 | 0.885 | .879 | |
| | P2 | | .874 | |
| | P3 | | .873 | |
| | P4 | | .871 | |
| | P5 | | .846 | |
| | P6 | | .643 | P6 |
| Responsiveness (R) | R3 | 0.946 | .861 | No items |
| | R1 | | .857 | |
| | R2 | | .851 | |
| Trust (T) | T1 | 0.907 | .923 | No items |
| | T5 | | .922 | |
| | T4 | | .920 | |
| | T2 | | .917 | |
| | T3 | | .914 | |

## 8. Conclusions and future works

The aim of this study was to propose and test three frameworks for achieving high quality mobile learning systems. Overall, the results of this study offer an empirical support for identifying the guidelines that contribute to design and development of high quality mobile learning systems based on students' perceptions. In addition, the results of this study help to identify the items of quality factors that meet students' needs and requirements of mobile learning systems, and thereby avoiding failure of post-implementation in the future. From the results in Table 4, the exploratory factor analysis showed that all items for the quality factors were discovered for achieving high quality mobile learning systems; except that one item (P6) was removed from the personalization factor due to the value of factor loadings being less than 0.7. Altogether, these quality factors are capable of determining high quality of the mobile leaning system that satisfies students' requirements; and therefore, these quality factors: system quality (functionality, accessibility, interactivity, interface design, and ease of use) information quality (content usefulness, and content

adequacy) and service quality (availability, personalization, trust, and responsiveness) contribute to the successful implementation of mobile learning systems. This study opens future work for using the identified quality factors as guidelines for researchers and designers to design and develop mobile learning applications.

## Appendix A. Questionnaire items

| Factors | Items | Measure |
|---|---|---|
| *Information quality items* | | |
| Content usefulness (CU) | CU1 | For mobile learning systems to be useful, it is important to provide text, audio and video content |
| | CU2 | For mobile learning systems to be useful, it is important to provide content that exactly fits your needs |
| | CU3 | For mobile learning systems to be useful, it is important to provide up-to-date content |
| | CU4 | For mobile learning systems to be useful, it is important to provide accurate content |
| Content adequacy (CA) | CA1 | For mobile learning systems to be useful it is important to provide complete content |
| | CA2 | For mobile learning systems to be useful it is important to provide sufficient content |
| | CA3 | For mobile learning systems to be useful it is important to provide complete service content |
| | CA4 | For mobile learning systems to be useful it is important to provide detailed contact information |
| *System quality items* | | |
| Functionality (F) | F1 | For mobile learning systems to be useful, it is important to be compatible with different platforms (Android, IOS) |
| | F2 | For mobile learning systems to be useful, it is important to have easy navigation |
| | F3 | For mobile learning systems to be useful, it is important perform easy search by text |
| | F4 | For mobile learning systems to be useful, it is important that the size and resolution of the interface is a good |
| Accessibility (AC) | AC1 | For mobile learning systems to be useful, it is important to have the ability to download files |
| | AC2 | For mobile learning systems to be useful, it is important to have the ability to upload files |
| | AC3 | For mobile learning systems to be useful, it is important to make it easy to access learning materials and services by using Wi-Fi |
| | AC4 | For mobile learning systems to be useful, it is important to make it easy to access learning materials and services by using 3G, 4G |
| Interactivity (IN) | IN1 | For mobile learning systems to be useful, it is important to make it easy to discuss with your teachers |
| | IN2 | For mobile learning systems to be useful, it is important to make easy to discuss with other students |
| | IN3 | For mobile learning systems to be useful, it is important to make it easy to share what you learn with the learning community |
| | IN4 | For mobile learning systems to be useful, it is important to make it easy to access the shared content from the learning community |
| Interface design (ID) | ID1 | For mobile learning system to be useful, it is important to provide attractive interface colors, graphics and animations |
| | ID2 | For mobile learning systems to be useful, it is important to provide visual features |
| | ID3 | For mobile learning systems to be useful, it is important to provide well-designed menus and icons |
| | ID4 | For mobile learning systems to be useful, it is important to provide a good page layout |
| Ease of use (EU) | EU1 | The mobile learning system is easy to use |
| | EU2 | Your interaction with the mobile learning system should be clear and understandable |
| | EU3 | Overall, mobile learning systems are user-friendly |
| *Service quality items* | | |
| Availability (AV) | AV1 | For mobile learning systems to be useful, it is important to provide learning content and services anywhere |
| | AV2 | For mobile learning systems to be useful, it is important to provide learning content and services any time |
| Personalization (P) | P1 | For mobile learning systems to be useful, it is important to provide the personalized messages from teachers and administrators |
| | P2 | For mobile learning systems to be useful, it is important to enable the user to learn the content they want |
| | P3 | For mobile learning systems to be useful, it is important to enable the user to choose how they want to learn |
| | P4 | For mobile learning systems to be useful, it is important to enable the user to control their learning progress |
| | P5 | For mobile learning systems to be useful, it is important to record your performance |

(*continued on next page*)

**Questionnaire items** (*continued*)

| Factors | Items | Measure |
|---|---|---|
| | P6 | For mobile learning systems to be useful, it is important to remember your preferences |
| Responsiveness (R) | R1 | For mobile learning systems to be useful, it is important to provide the user with prompt services |
| | R2 | For mobile learning systems to be useful, it is important to be always be ready to assist the user |
| | R3 | For mobile learning systems to be useful, it is important to provide the user information on exactly when the services will be performed |
| Trust (T) | T1 | For mobile learning systems to be useful, it is important to provide safe transactions |
| | T2 | For mobile learning systems to be useful, it is important to provide trustworthy services |
| | T3 | For mobile learning systems to be useful, it is important to provide adequate security features |
| | T4 | For mobile learning systems to be useful, it is important to not allow misuse of personal information |
| | T5 | For mobile learning systems to be useful, it is important to not allow misuse of privacy |

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