Investigating the Effect of m-Commerce Application's Functional and Non-Functional Attributes on Usability and Continuance Intention

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Abstract. The development of mobile commerce (m-commerce) applications has indicated a shift in goals from ease-of-use to sustainable use in the future. This shift has prompted changes in the combination of attributes that constitute the usability of m-commerce applications. This study developed an m-commerce usability model that combines functional and non-functional attributes. The research data was collected using questionnaires distributed to users living in Jakarta and was processed using the Partial Least Squares Structural Equation Modeling (PLS-SEM) technique. The results demonstrate that efficiency, satisfaction, and effectiveness can explain the usability of m-commerce applications. This study proved that three non-functional usability attributes – productivity, navigation, and memorability – have a positive effect on efficiency, while two functional attributes of usability – content and security – positively influence effectiveness. The study further proved that beside non-functional attributes, functional attributes also play an important role in increasing the user experience in the m-commerce context and thereby contribute to improving the usability of m-commerce systems and the continuance intention. The overall results of the study can be used in developing strategies for m-commerce application developers to design applications that can satisfy users and help them complete their tasks correctly and efficiently.

Keywords: *continuance intention; functional attributes; m-commerce; non-functional attributes; usability.*

1 Introduction

Mobile commerce, a common form of e-commerce, has been a growing trend during recent years. Mobile commerce (m-commerce) can be defined as selling and purchasing goods and services on online networks with the support of mobile devices [1]. These days many people use m-commerce to search information, make comparisons, and purchase products or services. The data published by

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www.statista.com shows that around 20 million people in Indonesia carried out online shopping activities in 2017, a number which continued to increase up to 85 million people by 2022 [2]. The development of m-commerce applications often results in a complex system with many functional features in the user interface [3]. The rich features do not always bring positive impacts from the perspective of the user experience because similar to e-commerce, m-commerce is different from face-to-face shopping experiences. It has lower cognitive load and is considered anonymous and impersonal [4]. Thus, it is necessary for companies and designers to better understand the functional and non-functional attributes of m-commerce applications that are perceived to be important for m-commerce users in order to gain a high level of user experience.

As the significance of mobile application usage has increased, the usability of mobile applications is becoming a fundamental factor in determining the success of m-commerce. Usability is defined by the International Standards Organization (ISO) as the extent to which a product can be used by specific users to achieve specific goals with effectiveness, efficiency, and satisfaction in a specific context of use [5]. By creating a seamless, user-friendly experience, a higher level of usability can increase customer satisfaction [6]. Further, according to Venkatesh, *et al.* [7], achieving excellent m-commerce usability is one of the biggest challenges. Venkatesh, *et al.* [7] identified the user experience as an important prerequisite for the success of m-commerce.

Continuance intention of m-commerce applications is a significant measure of m-commerce success. Continuance intention in mobile commerce refers to the constant and ongoing use of an application by its users. It is necessary for developers and businesses to create m-commerce platforms that provide features and experiences that could drive user's continuance intention. Considering the importance of achieving e-commerce user loyalty in different contexts, continuance intention has become an interesting research topic.

The novelty of this research is that it developed a usability model that incorporates functional and non-functional attributes of m-commerce applications as antecedents as well as continuance intention as the dependent variable. In this study, the influence of these functional and non-functional attributes on the usability of m-commerce applications was analyzed. Combining functional and non-functional attributes of m-commerce applications in the analysis facilitated a thorough evaluation of the mobile commerce user experience. This study also analyzed the relationship between usability and continuance intention. This holistic approach provided a comprehensive view of how well m-commerce applications align with user needs and expectations, and can be expected to increase continuance intention.

2 Model Development

A model was developed to analyze the most important factors that can explain the usability of m-commerce applications and the influence of the m-commerce usability on continuance intention. The model was developed based on the usability concepts of ISO 9241-11 [5]. This model was chosen because in it usability relates to the outcome of interacting with a system, product, or service, where usability is not defined as an attribute of a product. According to ISO 9241-11 [5] usability is how individual users can accomplish specific goals effectively, efficiently, and satisfactorily when utilizing a product within a given application context.

The model developed in this study is presented in Figure 1. The model incorporates functional and non-functional characteristics of m-commerce applications as antecedents. Functional usability attributes pertain to internal system characteristics that can impact the system's usability [8]. A system's internal attributes (functionality) can significantly impact its overall usability [9]. Guler [10] examined the relationship between functional characteristics and usability in the context of mobile applications. The present study highlighted the importance of considering functional attributes when developing usability models. Two functional usability attributes, namely security and content, were examined.

Meanwhile, non-functional attributes are external system attributes that emphasize usability factors, defined as the degree to which a website enables users to use its functions effortlessly and precisely. The non-functional usability attributes examined in this study were navigation, productivity, memorability, which were correlated with the investigated constructs. In the next section, a more detailed explanation of the model is presented.

2.1 Relationship between Usability and Continuance Intention

Continuance intention refers to the desire of the user to continue utilizing the mobile commerce services offered by an application [11]. This commitment materializes in the form of engagement with the m-commerce system in various transactional activities. Usability is a factor that can have a positive influence on continuance intention [12,13]. This underscores the idea that when m-commerce applications are user-friendly and provide significant utility, consumers are more inclined to remain loyal to them and continue using them in the future. When users have a positive experience with a mobile commerce system, they are more likely to keep using it and recommend it to others, which ultimately benefits the m-commerce application long-term success and user retention [14]. Based on this argument, the following hypothesis is proposed:

H1: Usability of m-commerce positively affects the continuance intention

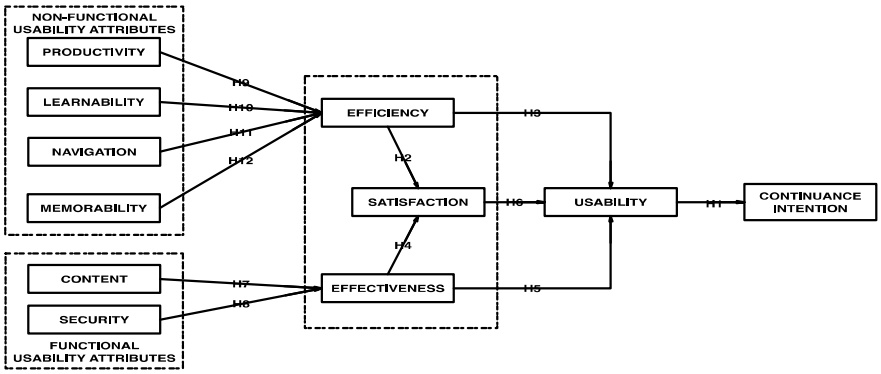

Figure 1 Conceptual Research Model

2.2 Usability

ISO 9241-11 [5] states that usability measures are determined by three attributes: efficiency, satisfaction and effectiveness. Efficiency is a crucial aspect that defines the ability of a system to provide high-level functionality and productivity by effectively utilizing resources and ensuring prompt task completion [15]. It encompasses factors such as the speed at which tasks are accomplished and the software's capacity to maximize available resources to achieve specific goals [16,17]. Efficiency is a key attribute considered in the development of usability models [18].

Further, Nelson & Stagger [16] and Matraf & Hussain [13] have stated that there is a significant correlation between efficiency and customer satisfaction in the context of mobile e-book applications. Efficient applications tend to provide a more comfortable, effective, and productive experience for users, which can naturally increase user satisfaction. Conversely, inefficiencies in an application can led to user dissatisfaction, reduced trust in the application, and even may lead to customer churn. Based on these arguments, the following hypotheses will be analyzed:

H2: Efficiency positively affects m-commerce's user satisfaction

H3: Efficiency positively affects the usability of m-commerce applications

Effectiveness of m-commerce systems is the capacity of the systems to enable users to perform certain activities accurately in specific situations. Effectiveness is measured based on the ability of users to accurately complete their task [18].

Effective use of a systems will lead to increased user satisfaction. Further, according to Anthony et al. [15] and Gupta et al. [17] effectiveness is a crucial factor that determines the overall usability value of a system [15]. Matraf & Hussain [13] argue that usability of m-commerce application can be assessed by its effectiveness. Based on these arguments, the following hypotheses are proposed:

H4: Effectiveness positively affects the satisfaction of m-commerce users

H5: Effectiveness positively affects the usability of m-commerce applications

Satisfaction refers to the comfort and attitudes of users towards using a m-commerce application. Several studies have considered satisfaction as an important factor in developing usability models [19]. It has been consistently proven that user satisfaction significantly influences the usability of mobile applications [9,19,20]. Based on these arguments, the following hypothesis is proposed:

H6: Satisfaction positively affects the usability of m-commerce applications

2.3 Impact of Content and Security on Effectiveness

Content and security are the m-commerce functional attributes that were included in the research model. Content is defined as the capability of an application to present information and perform transactions [21]. Content plays a crucial role in the usability evaluation [22]. The presentation of textual information is a significant aspect considered in usability models [8]. Further, a successful mobile commerce application demonstrates clarity and focus in its content, ensuring that the information provided is comprehensive and relevant [23]. In the context of mobile applications, content is considered a critical issue for users because users strongly rely on the application to access information that may not be available through traditional channels [8]. Therefore, m-commerce applications need to provide different types of content, such as textual, visual, and pictorial, that is relevant for the system's goals [22,24].

Further, Dawood, *et al.* [12] states the importance of resilience in software systems, which refers to their ability to perform operations accurately, to prevent failures and to ensure information and data security. This can be achieved by implementing various levels of system protection, such as access permissions for authorized users or systems and other security related procedures aimed at preventing access from unauthorized users or other software. Meanwhile, Dawood, *et al.* [12] has reported that safety is a determining factor for effectiveness. Based on the arguments above the following hypotheses are proposed:

H7: Content positively affects the effectiveness of m-commerce usage

H8: Security positively affects the effectiveness of m-commerce usage

2.4 Impact of Productivity, Learnability, Navigation and Memorability on Efficiency

Productivity, learnability, navigation, and memorability are non-functional attributes that were incorporated in the research model. Non-functional attributes are argued to affect the efficiency of using m-commerce applications. With this model, the influence of these four attributes on the efficiency of m-commerce applications was analyzed. Productivity is defined as the measure of the amount of output that users can get from using the software [12,24,25]. Abushark, *et al.* [26] states that productivity is an important attribute contributing to the overall usability value. Nelson & Staggers [16] state that productivity can assess the value of efficiency. Productivity measures the user's ability to complete tasks quickly and efficiently [24]. Therefore, m-commerce applications that facilitate productivity will help users to complete purchases or transactions more quickly, which will increase user efficiency in using the application.

Learnability is a crucial factor in assessing usability. It refers to the ease with which users learn and become proficient in using the functions of an m-commerce application [16,25,27], with minimal effort and time [11,12,26]. Learnability is an important attribute in the development of software applications [28] that is closely linked to efficiency in mobile applications. Nelson et al. [16] states that learnability significantly influences efficiency.

Users can navigate to carry out the tasks they have to carry out in a system through menus, graphical components, page sequences, and page layout. Effective navigation ensures that users can easily and efficiently find the information they are looking for related to tasks they have to do, which ultimately contributes to a positive user experience [15]. Navigation can prevent confusion and irrelevant searches, which may lead to poor sales [25]. Matraf & Hussain [13] examined the impact of navigation on user satisfaction with mobile e-book applications. Similarly, De Marsico & Levialdi in [29] concluded that navigation significantly impacts website efficiency. Nielsen [30] states that a well-designed navigation system helps users to reach their desired destination quickly, thereby improving shopping efficiency in mobile applications.

Memorability plays a crucial role in m-commerce applications, encompassing several important factors. It is defined as the capacity of a system to activate user intuition, enabling them to use diverse functions while minimizing reliance on memory [27]. Memorability involves the ability of the user to learn and remember various elements within the system, ensuring efficient usage over time [28]. In

software development, memorability is a significant factor for usability assessment [27,31]. Based on the arguments mentioned above, the following hypotheses are proposed:

H9: Productivity positively affects the efficiency of m-commerce usage

H10: Learnability positively affects the efficiency of m-commerce usage

H11: Navigation positively affects the efficiency of m-commerce usage

H12: Memorability positively affects the efficiency of m-commerce usage

3 Data Collection and Processing

3.1 Data Collection

Data collection was conducted during 4 weeks in November 2022 through an online questionnaire survey. The questionnaire was designed based on operational definitions of the research variables. Each question used a seven-point Likert-like scale ranging from strongly disagree (coded as 1) to strongly agree (coded as 7), with neutral (coded as 4) serving as the midpoint. It was assumed that the distances between neutral and agree as well as strongly disagree and disagree were equal.

Before being distributed, the draft questionnaire underwent a pre-testing phase with 11 users of m-commerce applications. The purpose was to ensure its clarity, legibility and content validity. A panel of experts who were also users revised the questionnaire to ensure that the respondents would understand the statement items. An expert is a person who has experience in survey research and has a good understanding of m-commerce applications. Subsequently, the questionnaire underwent a second round of testing with 40 users to establish its validity, reliability, and applicability. The test demonstrated that the updated questionnaire met the criteria. The final version of the questionnaire included 59 items. The questionnaire used in this study is provided in Appendix A.

The survey respondents were m-commerce users living in Jakarta, Indonesia. Purposive sampling was used with the purpose of getting respondents who were older than 20 years and had experience in purchasing online through m-commerce platforms at least 3 times. In total, 138 questionnaires were collected and used. This sample size was considered sufficient referring to a minimum sample size of 100 or 200 [32]. Demographic profile of the respondents is shown in Table 1.

Table 1 Profile of respondents.

Characteristic	Number	Percentage
Gender		
Male	77	55.79%
Female	61	44.21%
Age range		
21- 25	**59**	**42.75%**
25-34	39	28.26%
35-44	34	24.64%
45-44	6	4.35%
Last Education		
High School or equivalent	49	35.50%
Bachelor	**65**	**47.10%**
Master/Ph.D	24	17.40%

Characteristic	Number	Percentage
Mobile commerce transaction activities		
Bill payment	**75**	**75**
Mobile commerce transaction activities		
Voucher refill	68	68
Fashion shopping	49	49
Travel ticket	25	25
Financial transaction	9	9
Household and other needs shopping	14	14
Types of m-commerce applications that are often used		
Tokopedia	**74**	**53.62**
others	64	46.36

3.2 Data Processing and Analysis

3.2.1 Measurement Model Validation

The measurement model was assessed based on four main criteria, namely indicator reliability, internal consistency, convergent validity, and discriminant validity [33]. The first indicator, reliability, was tested by analyzing dependency among indicators. This criterion tests the reliability of indicators and determines the relationship between latent variables and indicators, which is indicated by the outer loading value of each indicator and is considered feasible if the minimum value is 0.7 [33].

Reliability testing in Smart PLS 3.0 can use two methods, namely Cronbach's alpha and composite reliability. According to Hair, *et al.* [34], the Cronbach's alpha coefficient and composite reliability must be greater than 0.7, although a value of 0.6 is still acceptable and a value ≥0.8 means the reliability is considered good. Table 2 shows that the Cronbach's alpha value ranged from 0.778 to 0.910 for the 11 latent variables and the composite reliability ranged from 0.857 to 0.921. These results indicate that the measurement model already had good composite reliability.

Table 2 Indicator assessment and descriptive statistics.

Construct	Item Indicator		Loading Factor	T-Statistics	Descriptive Statistics	
	Code	Item name			Mean	St.Dev
Usability (USA)	**USA1**	**Easy to understand**	**0.875**	**29.775**	**6.246**	**0.891**
	USA2	Simple to use	0.757	17.550	5.768	1.138
	USA3	Easy to find information	0.825	18.640	6.145	0.921
	USA4	Easy to navigate	0.863	21.996	6.022	0.967
	USA5	Ability of user to control	0.808	14.115	6.087	0.821
Memorability (MEM)	MEM1	Easy recollection after a substantial time lapse	0.844	20.437	6.065	0.980
	MEM2	Logical steps to achieve tasks.	0.823	20.417	6.065	0.980
	MEM3	**Comprehensibility**	**0.886**	**32.889**	**6.043**	**1.042**
Learnability (LRN)	LRN1	Time to learn	0.879	41.131	6.116	1.008
	LRN2	**Self-descriptiveness**	**0.888**	**25.413**	**6.080**	**0.993**
	LRN3	Minimum memory recall	0.817	25.789	6.123	0.928
Security (SEC)	**SEC1**	**Safety**	**0.802**	18.569	5.862	1.105
	SEC2	Error tolerance	0.774	16.596	5.964	1.045
	SEC3	Robustness to an internal error	0.761	18.741	5.319	1.330
	SEC4	Robustness to improper use	0.759	15.860	5.587	1.214
Content (CON)	CON1	Informative	0.808	22.535	5.964	0.981

Table 3 Construct reliability and validity assessment.

Construct	Cronbach's Alpha	Rho A	Composite Reliability	Average Variance Extracted (AVE)
Content	0.835	0.836	0.890	0.668
CI	0.861	0.866	0.915	0.782
Effectiveness	0.910	0.910	0.930	0.691
Efficiency	0.878	0.882	0.917	0.734
Learnability	0.826	0.828	0.896	0.742
Memorability	0.810	0.819	0.888	0.725
Navigation	0.896	0.901	0.921	0.660
Productivity	0.852	0.858	0.910	0.772
Satisfaction	0.885	0.891	0.916	0.687
Security	0.778	0.782	0.857	0.599
Usability	0.883	0.887	0.915	0.683

The second criterion was the internal consistency reliability of the measurement model, which was evaluated using the composite reliability value criterion. The

composite reliability values for all constructs ranged from 0.857 to 0.930 (Table 2). With a value exceeding 0.5, it can be concluded that a measurement model met the internal consistency criteria [33].

The third measurement model assessment criterion was the construct convergent validity, which was determined by the Average Variance Extracted (AVE) value with a value greater than 0.5, i.e., explaining more than 50 percent of the variation in the indicators [33]. Table 3 shows the AVE values for all constructs (ranging from 0.599 to 0.782), which means that the measurement model met the criteria for convergent validity.

The fourth criterion for evaluating the measurement model was discriminant validity, which verified the distinctiveness of each construct. This assessment involves two criteria. The first criterion examines the relationship between the indicators and the constructs, where the outer loading value of each indicator on its respective construct should surpass the cross-loading value of all other constructs [33]. With respect to the comparison between the outer loading and the cross-loading values, the outer loading value was higher for all indicators in the measurement model. The second criterion was the Fornell Larcker criterion, which guarantees that the AVE root value for each construct is greater than the one with the highest correlation [33]. The Fornell Larcker criterion compares the square root of the AVE values in Table 3 with the latent variable correlations in Table 4.

Table 4 Latent variable correlation.

Construct	CON	CUI	EFE	EFC	LRN	MEM	NAV	PRO	SAT	SEC	USA
Content	1.000	0.709	0.822	0.750	0.748	0.729	0.805	0.682	0.787	0.706	0.801
CI	0.709	1.000	0.818	0.829	0.763	0.725	0.803	0.825	0.818	0.673	0.815
Effectiveness	0.822	0.818	1.000	0.886	0.773	0.794	0.838	0.825	0.879	0.679	0.871
Efficiency	0.750	0.829	0.886	1.000	0.771	0.769	0.821	0.844	0.845	0.649	0.783
Learnability	0.748	0.763	0.773	0.771	1.000	0.835	0.817	0.767	0.849	0.641	0.847
Memorability	0.729	0.725	0.794	0.769	0.835	1.000	0.781	0.738	0.820	0.657	0.831
Navigation	0.805	0.803	0.838	0.821	0.817	0.781	1.000	0.810	0.861	0.712	0.859
Productivity	0.682	0.825	0.825	0.844	0.767	0.738	0.810	1.000	0.854	0.627	0.827
Satisfaction	0.787	0.818	0.879	0.845	0.849	0.820	0.861	0.854	1.000	0.704	0.904
Security	0.706	0.673	0.679	0.649	0.641	0.657	0.712	0.627	0.704	1.000	0.692
Usability	0.801	0.815	0.871	0.783	0.847	0.831	0.859	0.827	0.904	0.692	1.000

Based on the two criteria for examining discriminant validity, it could be concluded that each construct in this structure was completely distinct from the other.

3.2.2 Structural Model Evaluation

3.2.2.1 Hypothesis Testing

The model structure was assessed based on four criteria [34], namely the path coefficient, the coefficient of determination (R^2), the effect sizes (f2), and the predictive relevance (Q^2). To test the hypotheses, the statistical significance of the path coefficient was evaluated. Smart PLS3 utilizes bootstrapping to generate t-statistics and p-values [35]. For the significance testing of the structural pathway, a replacement bootstrap subsample of 5,000 was drawn from the original sample. The results of the hypotheses testing were analyzed using a one-way t-test with a significance threshold of 5% (0.05). The f2 (effect size) value of the research model indicates the magnitude of the influence of each exogenous construct on the endogenous construct.

Various criteria can be used to set limits for collinearity values. For instance, a value greater than 5 or greater than 10 suggests a potential for collinearity [36]. Table 5 displays the inner Variance Inflation Factor (VIF) values; it is noteworthy that all values were less than 10. This indicates that the results were not biased and there was no collinearity among the predictors in the preliminary study model. Furthermore, the correlation values of the latent variables, as shown in Table 5, support this conclusion. The correlations indicate no strong correlations (>0.9 or <-0.9) among the latent variables, which further confirms the absence of multicollinearity.

Table 5 Variance Inflation Factor (VIF).

Construct	CON	CUI	EFE	EFC	LRB	MEM	NAV	PRO	SAT	SEC	USA
Content	-	-	1.995	-	-	-	-	-	-	-	-
CI	-	-	-	-	-	-	-	-	-	-	-
Effectiveness	-	-	-	-	-	-	-	-	4.661	-	6.444
Efficiency	-	-	-	-	-	-	-	-	4.661	-	5.113
Learnability	-	-	-	4.450	-	-	-	-	-	-	-
Memorability	-	-	-	3.744	-	-	-	-	-	-	-
Navigation	-	-	-	4.172	-	-	-	-	-	-	-
Productivity	-	-	-	3.297	-	-	-	-	-	-	-
Satisfaction	-	-	-	-	-	-	-	-	-	-	4.826
Security	-	-	1.995	-	-	-	-	-	-	-	-
Usability	-	1.000	-	-	-	-	-	-	-	-	-

To assess the hypotheses, the statistical significance of the path coefficient was examined. Smart PLS3 employs bootstrapping to generate t-statistics and p-values [34]. For the significance testing of the structural pathway, a replacement bootstrap subsample of 5,000 was drawn from the original sample. The outcomes of the hypothesis testing, conducted using a one-way t-test and a significance threshold of 5% (0.05), are presented in Table 6.

According to Table 7, it can be concluded that the results could be considered favorable, since overall the independent variables could explain the high variability in the dependent variable: usability 84.7%, satisfaction 79.3%, efficiency 78.3%, effectiveness 69.5%, and continuance intention 66.4%.

Table 6 Structural model testing: direct effect/

Hypothesis	Path	Path Values (b)	t-Sat.	p-value (p)	Results
H1	USA ->CI	0.815	17.676	0.000	supported***
H2	EFC ->SAT	0.306	3.010	0.001	supported**
H3	**EFC ->USA**	**-0.146**	**1.908**	**0.028**	**not supported**
H4	EFE ->SAT	0.608	6.137	0.000	supported***
H5	EFE ->USA	0.428	3.770	0.000	supported***
H6	SAT ->USA	0.652	7.737	0.000	supported***
H7	SEC ->EFE	0.197	2.626	0.004	supported**
H8	CON ->EFE	0.682	9.128	0.000	supported***
H9	PRO ->EFC	0.450	5.202	0.000	supported***
H10	**LRN ->EFC**	**0.055**	**0.590**	**0.278**	**not supported**
H11	NAV ->EFC	0.272	3.220	0.001	supported**
H12	MEM >EFC	0.178	1.785	0.037	supported*

Notes: * $p < 0.05$; ** $p < 0.01$. *** $p < 0.001$.

Table 7 Summary of R^2 values.

	R-square	R-square Adjusted
Continuance Intention	0.664	0.662
Effectiveness	0.695	0.690
Efficiency	0.783	0.776
Satisfaction	0.793	0.790
Usability	0.847	0.844

The f2 effect size of the research model indicates the magnitude of the influence of each exogenous construct on the endogenous construct. Table 8 shows that the influence of satisfaction on the usability, of content on effectiveness, and of usability on continuance intention were substantial, because the f2 value was >0.35. The influence of effectiveness on satisfaction, of effectiveness on usability, and of productivity on efficiency could be considered moderate, because the f2 value was >0.15. On the other hand, the influence of security on effectiveness, of memorability on efficiency, of navigation on efficiency, of efficiency on satisfaction, and of effectiveness on usability could be considered negligible. However, the learnability construct was shown to have no impact on efficiency.

Table 8 Summary of f2 values.

Construct	CON	CUI	EFE	EFC	LRN	MEM	NAV	PRO	SAT	SEC	USA
Content	-	-	0.764	-	-	-	-	-	-	-	-
CI	-	-	-	-	-	-	-	-	-	-	-
Effectiveness	-	-	-	-	-	-	-	-	0.383	-	0.186
Efficiency	-	-	-	-	-	-	-	-	0.097	-	0.027
Learnability	-	-	-	0.003	-	-	-	-	-	-	-
Memorability	-	-	-	0.039	-	-	-	-	-	-	-
Navigation	-	-	-	0.082	-	-	-	-	-	-	-
Productivity	-	-	-	0.283	-	-	-	-	-	-	-
Satisfaction	-	-	-	-	-	-	-	-	-	-	0.577
Security	-	-	0.064	-	-	-	-	-	-	-	-
Usability	-	1.978	-	-	-	-	-	-	-	-	-

The results of the blindfolding process to assess the level of relevance of the predictions of the proposed model are shown in Table 9. Based on Table 9, all Q-square values for continuance intention, efficiency, effectiveness, satisfaction, and usability were more than 0. It could be concluded that the predictions for the efficiency, satisfaction, effectiveness, usability, and continuance intention constructs were appropriate or relevant.

Table 9 also shows the predicted relevance value (Q^2) of the research variables. The results showed that non-functional factors (productivity, learnability, navigation, and memorability) could explain efficiency as much as 54.7%. Likewise functional factors (content and security) could explain effectiveness as much as 46.4%. Further, efficiency and effectiveness could explain satisfaction as much as 52.2%. Efficiency, satisfaction, and effectiveness could explain usability as much as 56.4%. Finally, continuance intention could be explained by usability as much as 50.2%.

Table 9 Predictive Relevance (Q^2) values.

Construct	SSO	SSE	Q^2 (= 1-SSE/SSO)
Content	552,000	552,000	0.000
CI	**414,000**	**206,114**	**0.502**
Effectiveness	**828,000**	**444,084**	**0.464**
Efficiency	**552,000**	**250,270**	**0.547**
Learnability	414,000	414,000	0.000
Memorability	414,000	414,000	0.000
Navigation	828,000	828,000	0.000
Productivity	414,000	414,000	0.000
Satisfaction	**690,000**	**329,518**	**0.522**
Security	552,000	552,000	0.000
Usability	**690,000**	**300,618**	**0.564**

3.2.2.2 Model Fit

The model fit testing was carried out using several indices, including standardized root mean square residual (SRMR), NFI, Root Mean Square Theta (RMS Theta),

and Goodness of Fit (GoF). With SRMR criteria <0.08; RMS Theta <0.12; NFI >0.9; and GoF >0.38.

The results, as presented in Table 10, indicate that the RMS Theta or Root Mean Square Theta value of 0.143 was around 0.12, and the NFI value of 0.680 could be considered moderately fit. Based on these two model assessments, it was close to meeting the requirements of the model fit criteria. The model was fit based on the SRMR value 0.062 < 0.10. Thus, it could be concluded that the model fit the data. Finally the GoF value of the research model, which was 0.729, showed that this model had a high level of feasibility [38].

Table 10 Model Fit summary.

Assessment	Values	Criteria
D_ULS	4.212	>0.05
D_G	3.441	>0.05
SRMR	0.062	<0.08
NFI	0.680	Close to 1
Rms Theta	0.143	<0.12
GoF	0.729	>0.38

4 Discussion

This research showed that productivity, navigation, and memorability are three significant non-functional aspects of m-commerce systems that are necessary for efficient use of m-commerce applications. The non-functional aspects generally mean that the application allows users to use its functions easily and precisely [29]. These results are in line with the findings from Nelson & Staggers [16], who studied the influence of productivity on efficiency in the health sector. Learnability does not have a positive direct effect on efficiency. This is in contrast with earlier study's findings [6]. This could be related to the fact that many users may be already so much familiar with using different mobile applications that they have become proficient in using those applications and are not so sensitive anymore when judging the learning process for using new applications.

This study also highlighted the importance of two functional factors, namely content and security. When an application provides good quality content and security, it also means that the application operates according to its structure and makes users more effective in using the applications [16]. The functionalities of m-commerce applications that support user needs significantly determine user satisfaction. The study's results also showed that usability of m-commerce applications can be determined by satisfaction, effectiveness, and efficiency. Further, the study highlighted that satisfaction is the factor that has the strongest influence on usability, followed by effectiveness and efficiency. The usability

value (R^2) of 0.847 shows that 84.7% of usability could be explained by the predictor variables, which are efficiency, satisfaction, and effectiveness.

Continuance intention was found to be closely related to usability. This is in line with the results of previous research on mobile phone [8,9] mobile applications [37], online learning [10] and mobile applications [19,20]. Further, continuance intention had an R-square of 0.664, which shows that usability of an m-commerce application is a dominant factor in making users continue using the application.

The key strength of our proposed model is that it enhances the usability concept by separately analyzing the functional attributes and non-functional attributes as antecedents of the efficiency and effectiveness of m-commerce systems' usage. Further, the model developed also helps to analyze the contribution of each construct – efficiency, satisfaction, and effectiveness – on satisfaction and the continuance intention in the context of m-commerce usage. By combining all the aforementioned constructs in one comprehensive model, we developed a usability model that not only predicts customer needs effectively but also provides actionable insights that can be readily understood and acted upon by m-commerce system owners and developers.

5 Implications for Practice

When considering the importance of different usability factors, usability is an important aspect that can be evaluated during the software development process, to ensure continued product usage [12,13]. M-commerce application developers must ensure that productivity is considered appropriate when using an m-commerce application. Productivity can be expressed in terms of response time, loading time, and useful output. Developers should create simple and adaptive applications, resulting in fast loading times and response times with output that meets user expectations. Besides, navigation – which is expressed in terms of among others easy and efficient navigation, accessibility, and location – also should be addressed well. Good navigation can improve the user's ability to change the environmental structure and control content in real time. For this reason, developers should create applications with straightforward navigation to make them easier for users to use. Memorability indicates the application's capacity to support users to understand, obtain, and remember the operation of the m-commerce application system. It is also very important to improve the memorability of the systems by considering easy recall, logical steps, and comprehensibility when developing m-commerce applications.

M-commerce application developers must also pay attention to the effectiveness of system usage by enhancing content and security. This can be realized by providing informative, accurate, and complete content as well as media-choice

content for each transaction process from the time the user enters the application until the time when a transaction is completed. Complete content and security will help users easily make transactions, select product items, and choose payment method; integration with popular payment platforms will make it easier for users to carry out transactions comfortably.

6 Conclusion and Future Direction

The main contribution of this research is the reconceptualization of the usability concept by more comprehensively compiling factors that constitute usability, i.e., efficiency, satisfaction, and effectiveness. The study also contributed by proving that beside non-functional attributes of m-commerce applications – such as productivity, navigation, and memorability – functional attributes also play an important role in increasing user experience and thereby contribute to the improvement of m-commerce systems usability and continuance intention.

This study also showed that non-functional attributes of these systems are strongly related to efficiency while the functional attributes are significantly correlated with the effective use of m-commerce systems. These results can provide strategies for m-commerce application developers to design their applications to satisfy the users and help users to complete their tasks correctly. When an application has high usability according to the user wishes, users will tend to continue using it. Overall, this study showed that to get loyal users, m-commerce application developers must ensure that user usability requirements are met. A seamless experience in conducting m-commerce transactions through the application encourages continued usage.

This research had several limitations. First, it is better to use a probabilistic sampling technique so that the results are more representative and can be better generalized. Future studies should be done with a more comprehensive sampling method and expand the data collection to a wider population, to obtain more generalizable results. Further, future research should also incorporate more predictive factors from various theories and models to identify other important functional aspects of usability, such as social influence and simplicity, which could provide deeper insight into the complex dynamics of user behavior and intention to continue using mobile commerce applications.

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Appendix

Appendix A: Item Measuring

Item	Item Measure	Source
USA1	In this m-commerce application, everything is easy to understand.	Adapted from Thakur [36]
USA2	It is simple to use this m-commerce application even the first time I use this.	Adapted from Casalo et al. [21]; Thakur [36]
USA3	This m-commerce application helps me find the data I need quickly.	Adapted from Casalo et al. [21]; Thakur [36]
USA4	This m-commerce application content layout makes it simple for me to navigate through it and understand where I am.	Adapted from Casalo et al. [21]
USA5	I feel in control of my actions as I go around this website.	
MEM1	I still remember how to use the application functions even though I haven't used them in a long time.	Adapted from Dawood et al. [12]
MEM2	I did all the steps to quickly complete a specific transaction process.	
MEM3	This m-commerce application has clarity of elements (images, buttons), structure (sequences, steps), and functions.	Adapted from Gupta et al. [17]
LRN1	I was able to achieve my transaction goals when using this m-commerce application.	Adapted from Dawood et al. [12]
LRN2	This m-commerce application can provide appropriate support during my transactions.	
LRN3	This m-commerce application helps me make my transactions without remembering much about how to do it.	Adapted from Dawood et al. [12]
SEC1	This m-commerce application has an excellent ability to avoid risk when performing the transaction.	Adapted from Gupta et al. [17]
SEC2	This m-commerce application can prevent transaction errors from occurring.	
SEC3	This m-commerce application has never brought me into serious problems.	Adapted from Dawood et al. [12]
SEC4	This m-commerce application works well even after usage error.	
CON1	I think the m-commerce application contains up-to-date, clear, and detailed information.	Adapted from Ramanayaka et al. [11]; Muhammad et al. [25]
CON2	This m-commerce application gives true and accurate results.	Adapted from Muhammad et al. [25]
CON3	This m-commerce application has all the necessary support that I need.	Adapted from Ramanayaka et al. [11]
CON4	This m-commerce applications uses various ways (images, text, sound, etc.) to provide information.	
NAV1	This m-commerce application is easy to navigate, so I can quickly find relevant and exciting information according to my interests.	Adapted from Muhammad et al. [25]
NAV2	I can quickly perform operations after learning to use this m-commerce application.	
NAV3	I can access the m-commerce applications anytime and from anywhere.	
NAV4	The m-commerce application I use can show suggested activities or purchases according to my current location.	Adapted from Ramanayaka et al. [11]
NAV5	This m-commerce application has provided good guidance to access all main services	
NAV6	This m-commerce application has a clear sign for users to go to different parts of the apps.	
SAT1	This m-commerce applications keep me eager to use.	Adopted from Dawood et al. [12]; Gupta et al. [17]

Item	Item Measure	Source
SAT2	I am happy with that this m-commerce application works well when I process my transactions.	Adapted from Dawood et al. [12]
SAT3	I think the entire transaction process on the m-commerce application went smoothly.	
SAT4	All services in this m-commerce application can be done nicely.	Adapted from Singh et al. [24]
SAT5	I am happy that the m-commerce application's visual design is elegant and appealing.	
EFE1	Completing my transaction objectives with this m-commerce application is good.	Adapted from Dawood et al. [12]; Gupta et al. [17]
EFE2	This m-commerce application provides authentic and accurate results.	Adapted from Dawood et al. [12]
EFE3	This m-commerce application provides all the information and procedures I need to complete a particular transaction.	
EFE4	The m-commerce application gives me access to all the details and instructions I need for the transaction process.	
EFE5	This m-commerce application can keep up with my needs.	
EFE6	This m-commerce application works fine when I do some changes to suit my needs.	
EFC1	I feel that the performance and response time of the m-commerce application is good.	Adapted from Dawood et al. [12]
EFC2	This m-commerce application has provided me with all supports that I need.	Adopted from Dawood et al. [12]; Gupta et al. [17]
EFC3	This m-commerce application helps me to make transactions with minimum steps.	
EFC4	Appearance consistency between pages in the application is good. (images, icons, etc.) is good.	Adapted from Dawood et al. [24]
PRO1	The valuable output from my interaction with the m-commerce application is sound.	Adapted from Abushark et al. [26]; Gupta et al. [17]
PRO2	This m-commerce application has a fast-loading time for the application page.	Adapted from Singh et al. [24]
PRO3	I feel that this m-commerce application has a fast response time.	
CI1	I will often make transactions with this m-commerce application that facilitate good and complete transaction.	Mohamed et al. [39]
CI2	I will often use this m-commerce application that has given me good experience.	
CI3	I will often use this m-commerce application that has provided me with easy transactions.	