# Ethiopian Public Universities' Web Site Usability

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**Abstract.** Usability is the vital aspect of any system for having quality products. There are various models for testing usability. The objective of the study is to assess the applicability of the USE (Usefulness (Usability), Satisfaction, Ease of use, and Ease of learning) model for Ethiopian Universities' web site context. The USE model is evaluated using PLS-SEM method. The study uses three university web sites to test the model. The result found is encouraging. It has found that usability is affected by 53.3% jointly by the considered usability factors. Independently, usability is influenced by user satisfaction, ease of use, and ease of learning by 53.1%, 20.1%, and 6.1% respectively. Based on the result found, user satisfaction is the major determinant for web site usability and the "USE" model is convenient to study web site usability of Ethiopian universities.

**Keywords:** "USE" · Web site usability · User satisfaction · Ease of use
Ease of learning · PLS-SEM

## 1 Introduction

The concept of usability is defined by different scholars in a similar manner with a little bit difference. According to Jafari and Sheehan (2002) cited in [13], usability is defined as the extent to which a system supports its users in completing their tasks efficiently, effectively and satisfactory. Usability on the web, may be extended to include ideas like speed, clarity, intuitiveness of navigation, ease of use, readability and personalization.

Usability refers to terms such as ease of use and ease of learning that implied providing users with systems requiring minimum cognitive and physical effort to accomplish users' needs and expectations (Sindhuja and Surajith (2009) cited in [11]).

In the view of ISO cited in [12], usability is "the extent to which a product can be used by specified users to achieve specific field goals with effectiveness, efficiency, and satisfaction in a specified context of use". Usability can also viewed as "a set of attributes[1]" that collectively assess the usability of a product/website.

[1] Attribute, factor, construct, latent variable, usability aspect, usability dimension refer the same concept.

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The Institute of Electrical and Electronics Engineers (IEEE) also defines usability as "the ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or component" IEEE cited in [12].

Usability specifies how easily an object is used. The object can be anything; that is, a machine, process, software application, tool, book or website. Anything, with which a person can interact, should be usable. In case of software applications and websites, usability has been stated as the simplest way by which an average person can use the software or website to achieve certain goals [9].

This research focused on the applicability of the "USE" model. The method concentrates on the attributes of usability; namely, Usefulness (Usability), Satisfaction (User satisfaction), Ease of use, and ease of learning. For assessing "USE" usability method, three university web sites are taken into consideration [1, 2, 5].

The study answers the questions: Whether usability is determined by user satisfaction, ease of use, and ease of learning, and by the combined effect of user satisfaction, ease of use, and ease of learning.

## 2 Materials and Methods

### 2.1 Structural Equation Modeling

Structural Equation Modeling (SEM) is a multivariate technique combining aspects of multiple regression (examining dependence relationships) and factor analysis (representing unmeasured concepts-factors with multiple variables) to estimate a series of interrelated dependence relationships simultaneously [8]. SEM is a more powerful multivariate analysis technique that creates greater flexibility that researchers have with the interplay of theory and data ([14] citing Chin 1998). Data analysis using SEM procedures can incorporate both unobserved (latent) and observed variables, but the former data analysis methods (linear regression, ANOVA, MANOVA) are based on observed measurements only [8].

[15] has noted that there are two sub-models in a structural equation model; the inner model and the outer model. The inner model specifies the relationships between the independent and dependent latent variables and the outer model specifies the relationships between the latent variables and their observed indicators. In SEM, a variable is either exogenous or endogenous. An exogenous variable has path arrows pointing outwards and none leading to it. Meanwhile, an endogenous variable has at least one path leading to it and represents the effects of other variable(s). The SEM model showing the inner Vs outer models and exogenous and endogenous latent variables is indicated below in Fig. 1.

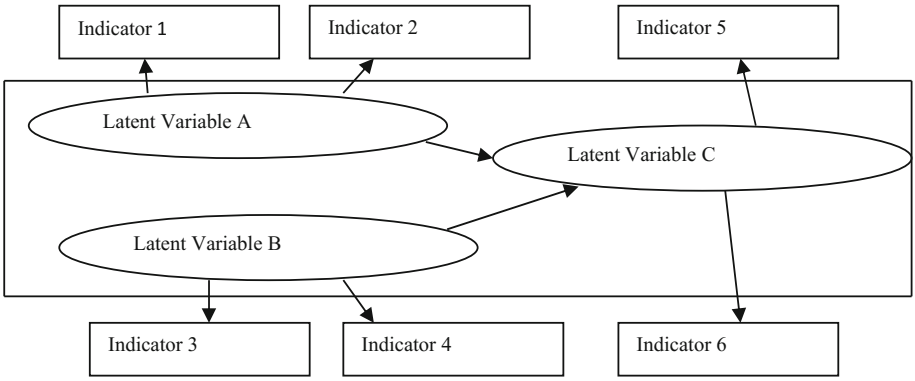


**Fig. 1.** Inner vs. outer model in SEM

Note: In Fig. 1, elements found inside the box are called inner or structural model; out of the box it is called outer or measurement model.

**Partial Least Square-Structural Equation Modeling (PLS-SEM).** According to [15], PLS is useful for structural equation modeling in applied research projects even when there are limited participants. PLS is a soft modeling approach to SEM with no assumptions about data distribution. PLS-SEM has been deployed in many fields including behavioral sciences and information system. In this study, among the different approaches of SEM (Covariance based, competent based and variance based), the analysis of variance based approach of the PLS-SEM is used using the SmartPls software.

## 2.2 The Model

The model is based on [10] usability questionnaire and it is called "USE". "USE" stands for usefulness (usability), satisfaction (user satisfaction), ease of use, and ease of learning. Each of the attributes are described by items or indicators. There are 25 indicators that explain the latent variables (independent and dependent). Respondents are asked to rate each indicator using five point Lickert scale (Strongly disagree, Disagree, Neutral, Agree, Strongly agree). The indicators or items for each attribute or latent variable are indicated below.

Usability items

1. The web site helps me to be more effective (U1)
2. The web site helps me to be more productive (U2)
3. The web site is useful (U3)
4. The web site gives me more control over the activities in my life (U4)
5. The web site saves me time when I use it (U5)
6. The web site meets my needs (U6)
7. The web site does everything I would expect it to do (U7)

Ease of use items

1. The web site is easy to use (eu1)
2. The web site is user friendly (eu2)

3. The web site requires the fewest steps possible to accomplish what I want to do with it (eu3)
4. Using the web site is effortless (eu4)
5. I can use the web site without written instructions (eu5)
6. I don't notice any inconsistencies when I use the web site (eu6)
7. I can recover from mistakes quickly and easily when using the web site (eu7)
8. I can use the web site successfully every time (eu8)

Ease of Learning items

1. I learned to use the web site quickly (el1)
2. I easily remember how to use the web site (el2)
3. The web site is easy to learn to use it (el3)
4. I quickly became skillful with the web site to use it (el4)

User Satisfaction items

1. I am satisfied with the web site (s1)
2. I would recommend the web site to a friend (s2)
3. The web site is enjoyable to use (s3)
4. The web site works the way I want it to work (s4)
5. The web site is wonderful (s5)
6. I feel I need to use the web site (s6)

The following diagram (Fig. 2) shows model of this study, which shows usability and its determinants (ease of use, ease of learning, and user satisfaction) and indicators of each latent variable.

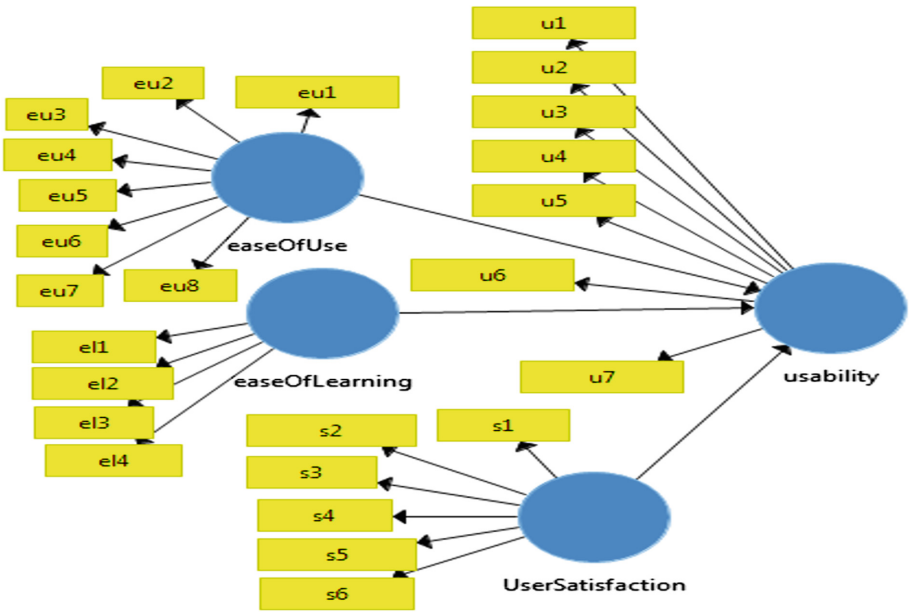


**Fig. 2.** The study model

### 2.3 The Data

In accordance with [15], the number of arrows pointing at a latent variable in the model determines, the number of samples to be taken. For a model having 8 arrows pointing at a latent variable in the model, a minimum of 84 samples are required. Since, increasing the sample size increases the model performance, more samples have been taken.

The experiment is done with four categories of data. The first experiment is using Addis Ababa University (AAU) Web site data, the second one is using Bahir Dar University (BDU) web site data, the third experiment is by using Gondar University (GU) web site data, and the final experiment is by merging data collected from the three universities.

The data is collected from undergraduate graduating class students. The reason is that graduating class students have better experience of using their university's web site. The assessment of "USE" method is based on this data collected using questionnaire.

The total data amounts to 541 from 3637 population. 212 data is collected from Addis Ababa University (1344 population), 160 samples are taken from Bahir Dar University (1173 population), and 169 data is collected from Gondar University (1120 population).

## 3 Results

### 3.1 Inner Model Coefficients

Path coefficients are numbers on the arrows connected from the independent latent variables (ease of use, ease of learning, user satisfaction) to the dependent latent variable (usability). Refer Fig. 2. Table 1 below shows such results.

**Table 1.** Inner model path coefficients

| | Usability | | | | |
|---|---|---|---|---|---|
| | AAU | BDU | GU | All | Average |
| UserSatisfaction | 0.541 | 0.412 | 0.608 | 0.564 | 0.531 |
| easeOfLearning | 0.101 | 0.110 | −0.016 | 0.047 | 0.061 |
| easeOfUse | 0.209 | 0.272 | 0.142 | 0.181 | 0.201 |

In Table 1, AAU means Addis Ababa University, BDU means Bahir Dar University, GU means Gondar University. and All represents all the 3 universities data combined together.

Positive numbers indicate that positive impact on usability. Only ease of learning has inverse relationship in Gondar University data. In all the data categories, user satisfaction is the highest, ease of use is the second and ease of learning with the least path coefficient result.

Based on the result, user satisfaction is the major determinant for usability, ease of use is the second determinant, and finally ease of learning.

Table 2 shows T statistics values, which tests the significance of the path coefficients obtained above in Table 1. T statistics value greater than 1.96 at 0.05 confidence interval indicates the value has significant impact [4]. Thus, on average, user satisfaction and ease of use have significant impact on usability. Whereas, ease of learning is not significant determinant for web site usability.

**Table 2.** Inner model coefficients significance test

| | T statistics | | | | |
|---|---|---|---|---|---|
| | AAU | BDU | GU | All | Average |
| UserSatisfaction → usability | 8.0 | 5.0 | 6.2 | 12.7 | 8.0 |
| easeOfLearning → usability | 1.8 | 1.1 | 0.1 | 1.00 | 1.0 |
| easeOfUse → usability | 2.6 | 2.7 | 1.4 | 3.54 | 2.5 |

### 3.2 Outer Model Coefficients

Outer model or measurement model shows indicator reliability to measure the indicated latent variable. They show the paths from a factor to its representative indicator variables (refer Fig. 2). The coefficients are said to be outer loadings, which reflects contribution of the indicator to the latent variable. The square of the coefficients gives the reliability of the indicator. For a well-fitted reflective model, path loadings should be above 0.70 (Henseler et al. 2012 cited in [4]). On the other hand, if outer loading of an indicator is greater than 0.50, it is sufficient [6].

Each indicator's outer loading is greater than 0.5. Some values with less than 0.5 outer loading result are shown in Table 3 below (shaded ones). Based on Table 3, eu4 and eu5 are slightly below 0.5 on average. Others are above 0.5 on average.

**Table 3.** Outer loading of indicators

| | AAU | BDU | GU | All | Average |
|---|---|---|---|---|---|
| **eu4** | 0.585 | 0.461 | 0.289 | 0.461 | 0.449 |
| **eu5** | 0.611 | 0.507 | 0.247 | 0.448 | 0.453 |
| **eu6** | 0.618 | 0.578 | 0.293 | 0.521 | 0.503 |
| **u5** | 0.766 | 0.258 | 0.76 | 0.512 | 0.574 |

When the significance is tested, all outer loading value is significant on average which portrays that the indicators are representative.

### 3.3 Measurement or Outer Model Fit

In Fig. 2, arrows go from the factor (ease of use, ease of learning, user satisfaction and usability) to the indicator variables, determines the values of the measured and representative indicator variables. The model fit of this can be done using Composite Reliability, Cronbach's Alpha, Average variance extracted (AVE), The Fornell–Larcker Discriminant Validity criterion, the Standardized Root Mean Square Residual (SRMR), and Heterotrait-Monotrait Ratio (HTMT). The result found is presented below in the following sections.

**Composite Reliability.** Composite reliability is a test of convergent validity in a reflective model. The result of composite reliability is depicted as follows in Table 4.

**Table 4.** Composite reliability

| | Composite reliability | | | |
|---|---|---|---|---|
| | AAU | BDU | GU | All |
| UserSatisfaction | 0.934 | 0.900 | 0.904 | 0.921 |
| easeOfLearning | 0.908 | 0.891 | 0.881 | 0.894 |
| easeOfUse | 0.879 | 0.830 | 0.767 | 0.835 |
| Usability | 0.901 | 0.869 | 0.909 | 0.883 |

Composite reliabilities should be equal to or greater than 0.6 as indicated by Chin 1998; Höck and Ringle 2006 cited in [4]. Based on this, the result indicates that indicators explain the latent variables well.

The significance test for composite reliability is shown below in Table 5. Since all the values are greater than 1.96, composite reliability is significant.

**Table 5.** Significance test for composite reliability

| | T statistics | | | |
|---|---|---|---|---|
| | AAU | BDU | GU | All |
| UserSatisfaction | 121.339 | 61.202 | 65.343 | 154.070 |
| easeOfLearning | 69.405 | 49.251 | 32.157 | 96.691 |
| easeOfUse | 61.991 | 41.243 | 10.953 | 65.801 |
| Usability | 66.682 | 42.342 | 73.138 | 58.609 |

**Cronbach's Alpha.** Cronbach's alpha addresses the question of whether the indicators for latent variables display convergent validity and hence display reliability. The result of this study is shown below in Table 6.

**Table 6.** Cronbach's alpha

| | Cronbach's alpha | | | |
|---|---|---|---|---|
| | AAU | BDU | GU | All |
| UserSatisfaction | 0.915 | 0.866 | 0.872 | 0.896 |
| easeOfLearning | 0.866 | 0.839 | 0.824 | 0.844 |
| easeOfUse | 0.843 | 0.771 | 0.716 | 0.783 |
| Usability | 0.869 | 0.818 | 0.882 | 0.843 |

The same cut off applies like composite reliability. So, the indicators are representatives of the latent variables.

Table 7, here under shows T statistics for Cronbach's Alpha. All values are greater than 1.96, which shows Cronbach Alpha values are significant at 0.05 confidence interval.

**Table 7.** Significance test for Cronbach's alpha

| | T statistics | | | |
|---|---|---|---|---|
| | AAU | BDU | GU | All |
| UserSatisfaction | 85.167 | 39.241 | 42.648 | 104.983 |
| easeOfLearning | 41.259 | 28.465 | 26.246 | 55.554 |
| easeOfUse | 40.748 | 26.343 | 15.354 | 47.086 |
| Usability | 43.733 | 24.916 | 49.968 | 62.631 |

**Average Variance Extracted (AVE).** AVE may be used as a test of both convergent and divergent validity. AVE reflects the average communality for each latent factor in a reflective model. In an adequate model, AVE should be greater than 0.5 (Chin 1998; Höck and Ringle 2006 cited in [4]).

Table 8 shows AVE is better for the 4 latent variables; whereas, slightly below the cut off for ease of use.

**Table 8.** Average variance extracted

| | Average variance extracted | | | |
|---|---|---|---|---|
| | AAU | BDU | GU | All |
| UserSatisfaction | 0.703 | 0.602 | 0.612 | 0.660 |
| easeOfLearning | 0.713 | 0.673 | 0.650 | 0.680 |
| easeOfUse | 0.479 | 0.386 | 0.321 | 0.396 |
| Usability | 0.572 | 0.504 | 0.593 | 0.526 |

Table 9 shows T statistics for AVE. Based on the result, all values are significant.

**Table 9.** Significance test for AVE

| | T statistics | | | |
|---|---|---|---|---|
| | AAU | BDU | GU | All |
| UserSatisfaction | 27.6 | 16.0 | 16.8 | 36.5 |
| easeOfLearning | 22.6 | 16.8 | 14.1 | 32.1 |
| easeOfUse | 15.2 | 12.8 | 7.3 | 19.8 |
| Usability | 15.2 | 12.7 | 17.2 | 14.7 |

**The Fornell–Larcker Discriminant Validity Criterion.** The Fornell-Larcker criterion table shows the square root of AVE appears in the diagonal cells and correlations appear below it. Therefore, in absolute value terms, if the top number (which is the square root of AVE) in any factor column is higher (which is the case in this study) than the numbers (correlations) below it, there is discriminant validity. Table 10 below shows the result in this study.

**Table 10.** The Fornell-Larcker discriminant validity

| | UserSatisfaction | easeOfLearning | easeOfUse | Usability |
|---|---|---|---|---|
| | Average | Average | Average | Average |
| UserSatisfaction | 0.802 | | | |
| easeOfLearning | 0.589 | 0.823 | | |
| easeOfUse | 0.683 | 0.680 | 0.627 | |
| Usability | 0.705 | 0.508 | 0.604 | 0.740 |

**The Standardized Root Mean Square Residual (SRMR).** SRMR is a measure of approximate fit of the researcher's model. It measures the difference between the observed correlation matrix and the model-implied correlation matrix. By convention, a model has good fit when SRMR is less than 0.08 [7].

For this study, SRMR values are 0.064 for AAU data, 0.077 for BDU data, 0.213 for GU data, and 0.063 for All data combined together. Based on the cut off (0.08), all the models are good except the result for Gondar University data. The significance test result is indicated below in Table 11.

**Table 11.** Significance test for the standardized root mean square residual

| | T statistics | | | |
|---|---|---|---|---|
| | AAU | BDU | GU | All |
| Saturated model | 17.1 | 14.9 | 13.5 | 33.4 |
| Estimated model | 23.5 | 23.2 | 12.7 | 19.6 |

Table 11 shows significance result. All T value is above 1.96. Hence, the model is appropriate.

**Heterotrait-Monotrait Ratio (HTMT).** Henseler et al. 2015 cited in [4] suggest that if the HTMT value is below 0.90, discriminant validity has been established between a given pair of reflective constructs. Clark and Watson use the more strict cutoff of, which is 0.85 [3]. Based on the cut offs, the result of the study shows discriminant validity is established as indicated in Table 12 below.

**Table 12.** Heterotrait-Monotrait ratio

| | User satisfaction | easeOfLearning | easeOfUse |
|---|---|---|---|
| | Average | Average | Average |
| easeOfLearning | 0.625 | | |
| easeOfUse | 0.700 | 0.775 | |
| Usability | 0.750 | 0.525 | 0.625 |

The significance is high as indicated below on Table 13.

**Table 13.** Significance test for Heterotrait-Monotrait ratio

| | T statistics | | | |
|---|---|---|---|---|
| | AAU | BDU | GU | All |
| easeOfLearning → UserSatisfaction | 11.1 | 13.5 | 7.3 | 17.7 |
| easeOfUse → UserSatisfaction | 28.4 | 16.9 | 9.7 | 26.0 |
| easeOfUse → easeOfLearning | 18.9 | 11.8 | 12.4 | 24.2 |
| usability → UserSatisfaction | 24.1 | 14.6 | 14.3 | 33.8 |
| usability → easeOfLearning | 10.8 | 7.70 | 4.55 | 12.0 |
| usability → easeOfUse | 17.6 | 11.4 | 7.6 | 18.6 |

### 3.4 Goodness of Fit for the Structural Model

Structural fit is examined only after measurement fit is shown to be acceptable. In this study, the measurement or outer model is accepted. Hence, the inner model is assessed. The structural or inner model consists of the factors and the arrows that connect one factor to another (in this context ease of use to usability, ease of learning to usability and user satisfaction to usability). R-square and R-square adjusted shows goodness of the structural model.

**R-square and R-square Adjusted.** R-square, also called the coefficient of determination, is the overall effect size measure for the structural model.

**Table 14.** R-square and R-square adjusted

| | R square | | | | | R square adjusted | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | AAU | BDU | GU | All | Average | AAU | BDU | GU | All | Average |
| Usability | 0.603 | 0.506 | 0.486 | 0.535 | 0.533 | 0.597 | 0.506 | 0.477 | 0.532 | 0.528 |

As shown in Table 14, R-square value for AAU data is 0.603, meaning that about 60.3% of the variance in usability is explained by the model; that is, jointly by user satisfaction, ease of learning and ease of use; 50.06% for BDU data, 48.6% for GU data, 53.5% for all the data, and 53.3% on average.

Note that adding predictors to a PLS-SEM model tends to increase $R^2$, even if the added predictors have only trivial correlation with the endogenous variable. To penalize for such a bias, adjusted $R^2$ may be used [4]. Hence, Smaller $R^2$ values are shown in $R^2$ adjusted than original $R^2$ values as indicated in Table 14.

Chin 1998: 323; Höck and Ringle 2006 cited in [4] describes results above the cutoffs 0.67, 0.33 and 0.19 to be "substantial", "moderate" and "weak" respectively. The R-square here would be considered to be of moderate strength or effect. Based on this, both R-square and R-square adjusted have moderate effect in this study.

The significance of R-square and R-square adjusted are shown by Table 15.

**Table 15.** Significance test for R-square and R-square adjusted

| | T statistics R-square | | | | T statistics R-square adjusted | | | |
|---|---|---|---|---|---|---|---|---|
| | AAU | BDU | GU | All | AAU | BDU | GU | All |
| Usability | 13.0 | 8.3 | 7.8 | 16.6 | 12.6 | 8.0 | 7.5 | 16.4 |

The result shows, R-square value obtained is significant. Hence, we can say that usability is significantly affected by ease of use, ease of learning, and user satisfaction.

## 4 Discussion

The result found is good. The USE model can be applied for studying web site usability. The model considers three latent variables to measure usability. These are: ease of use, ease of learning, and user satisfaction. Each of the latent variable is represented by indicators. Indicators reflect the reality of the latent variables. Usability is also represented by its own indicators. Throughout the course of this study, the importance of indicators representation for its own latent variable is seen and the importance of each latent variable has been studied.

The study experiment is carried out in 4 dataset categories: AAU data, BDU data, GU data, and All data. The total data is amounted to 541. The model is appropriate based on model fit results found. So, it is legitimate to discuss the results found and come up with conclusions and recommendations.

The indicators represent the latent variables well but the representation of three indicators for Gondar university data is not significant. These are ease of use 4, 5, and 6. These three indicators are items of ease of use. The variables or indicators are: ease of use 4 (Using the web site is effortless), ease of use 5 (I can use the web site without written instructions), and ease of use 5 (I don't notice any inconsistencies when I use the web site). This result occurred only for Gondar university data. The other one is the impact of usability 5 is not significant for Bahir Dar University data. This indicator is: The web site saves me time when I use it. When the average is considered from the four experiments the indicators are better representative of the latent variables.

Based on the experiments, it is found that the three latent variables have positive effect on usability. One exceptional result is ease of learning negatively related to usability in Gondar university's data.

Though the result indicates positive relationship, ease of learning has no significant impact on usability. User satisfaction and ease of use has significant impact on usability. Here again, Gondar University data shows insignificant impact of ease of use for usability. User satisfaction resulted higher relationship with usability followed by ease of use and ease of learning. The combined effect of all the three latent variables (ease of use, ease of learning, and user satisfaction) on usability is significant.

The following recommendations are forwarded that are thought to improve the result and discover different aspects.

In this study 25 indictors are used to represent factors or latent variables. Additional indicators may be employed for factor representation. Even different indicators for the same construct can be employed and the effect can be tested.

In this study, three aspects of usability has been studied. Other factors like memorability, efficiency, error, etc. can be included for usability study.

The path model used in this study is from the latent variables (ease of use, ease of learning, user satisfaction) to usability. Other path models can be used and the effect can be seen to test usability.

The model used can be seen by increasing the number of data and the number of universities in order to improve the result.

This study is done on educational web site. The study can be extended to assess usability model based on different types of web sites like: e-commerce web sites, government web sites, etc.

The model can also be tested on software products other than web sites. The products can be web applications or desktop applications like registrar systems, financial systems, human resource systems, etc.

The method employed for this study is PLS-SEM. Different methods can be used for testing the model, like: PLS regression, CB-SEM.

The questionnaire used in this study is 5 point licker scale (strongly agree, agree, neutral, disagree, strongly disagree); specially, for the indicator variables. Seven point licker scale (strongly agree, somewhat agree, agree, neutral, somewhat disagree, disagree, strongly disagree) can also be tried to test the model.

## 5 Conclusion

Usability is at the heart of any product for continuous improvement. Different methods are available for usability measurement. The one which is assessed in this study is USE model for usability. Based on the results found the following conclusions are made.

- The assessment of model indicated that the structural equation model used is appropriate.
- It is found that the selected indicators based on USE model are better representatives of the factors of usability or latent variables (ease of use, ease of learning, user satisfaction).
- Usability is highly determined by user satisfaction. The contribution of user satisfaction is 53.1% on average. Hence, user satisfaction is the major determinant for usability.
- Ease of use has 20.1% impact on usability and this impact is significant. The result shows ease of use of web sites is the second important factor for maximizing usability of web sites.
- Even though ease of learning has 6.1% contribution on usability on average, the effect is not significant. This does not mean that ease of learning has nothing to do with web site usability. Ease of learning has some effect but it is less than other factors and not significant enough.

- The combined effect of ease of use, ease of learning, and user satisfaction on usability is significant. The result based on R-square indicated that usability is expressed by the three factors by 53.3%. The result shows the three factors have paramount importance but still there are other remaining factors that can maximize usability of web sites.
- Using the result benchmark we can conclude that USE model can be applied for evaluating university web sites usability in particular and any web site in general.

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