Performance Factors Impacting Web-Based Learning Support Systems

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ABSTRACT

Web-based course management systems have been overwhelmingly accepted by instructors, students, and educational institutions. In order to improve quality of existing systems**,** the questions must be answered are what underlying dimensions of user's satisfaction exist and on which of those dimensions we should apply the resources. In this study, the principal component analysis was undertaken to determine the underlying dimensions. Then the scores for each dimension were calculated, and bivariate correlations between the dimensions and the user's satisfaction were used to assess the marginal importance of each dimension in improving web course management systems. In addition, the survey instrument was tested for reliability and validity.

Keywords: Web-based Learning Support Systems, Marginal Importance, Principal Component Analysis, and User Satisfaction.

1. INTRODUCTION

Information technology is becoming an increasingly important part of distance learning as well as traditional classroom education. In order to improve quality of existing systems, the questions must be answered are what underlying dimensions of user's satisfaction exist and on which of those dimensions we should apply the resources.

Previous research explored difference between computer-based teaching methods and traditional teaching methods in terms of class interaction and in-class learning, and found that the use of computer-based teaching methods requiring hands-on student use appear to offer an advantage over traditional methods [12]. Alavi [1] found that computer-mediated collaborative learning led to higher levels of perceived skill development, self-reported learning, and evaluation of classroom experience.

As Web-based online tests become more and more popular and acceptable, research on comparison of paper-and-pencil and computer-based testing is of interest to educational administrators and instructors as well. A computer-based test can be equivalent to a paper-and-pencil test if it meets stringent criteria, and computers affect tests [2]. The delivery of educational materials is undergoing a remarkable change from the traditional lecture method to dissemination of courses via the Web-based teaching-support systems [14]. A good Web-based teaching-support system should integrate sound pedagogical practice into the Web authoring process [8].

A Web-based teaching-support system is essentially an information system. Prior research has paid much attention to acceptance of information systems. The technology acceptance model (TAM) revealed causal linkages between two fundamental determinants (perceived usefulness and perceived ease of use) and system usage [4] [5]. Jackson et al. [8] extended TAM to TAME (technology acceptance model extension) by adding a new determinant (user involvement). However, since the Web-based teaching-support system is educational in nature, it is different from most of information systems. The most valuable activity in education is the opportunity for students to work and interact together [9]. The prior work therefore needs an extension by adding a construct – "interaction among students and instructors." System responsiveness and availability are important characteristics of Web-based teaching-support systems. The construct "responsiveness of system" was also investigated in this study. The purpose of this study is to improve an existing Web-based teaching-support system. Since no students were involved in development of existing system, the construct "user involvement" was not included in this study. Transmitting knowledge and develop problem solving and critical thinking skills are the most important achievement of education. The component "perceived usefulness" was therefore integrated into component "interaction among students and instructors."

A survey form was developed by a group of course instructors and system developers regarding improvement of the existing Web-based teaching-support system − the Web Course Management System (WCMS) at a public school in Virginia. The principal component analysis was applied to the survey data. Three components ("interaction among students and instructors", "ease of use", and "responsiveness of systems") were extracted from the data set. Correlations between component scores and user's satisfaction scores discovered marginal importance of individual components. The components and their marginal importance could extend knowledge of educational administrators and system developers beyond the mere responses to the items in the questionnaires, and help them improve the existing WCMS. All three scales demonstrated high convergent validity, discriminant validity, factorial validity, and internal consistency reliability.

2. DATA AND METHODOLOGY

Data were supplied by a convenient sample of 102 students majored in Information Systems from a public school in Virginia. Data were collected by the end of semester. The sample contained students of freshman to senior classes. Since the survey was administered by instructors, the return rate was 100%. The survey form (Appendix) included fifteen questions and employed a five-point Likert scale ranging from Strongly Disagree to Strongly Agree. The last question in the survey form was user's overall satisfaction with the Web-based Course Management System (WCMS). Therefore, bivariate correlations between the underlying dimensions and the user's satisfaction could be calculated and used to assess the marginal importance of each dimension for improvement of the WCMS. The questionnaire items were selected by a group of course instructors and system developers regarding the potentials of the WCMS improvement.

In order to answer the opening questions, this study was carried out in three stages. In Stage 1, the principal component analysis using orthogonal rotation was performed on the first fourteen survey items. When those variables were correlated with one another, they were possibly measuring the same construct. In this case, redundancy might exist in those variables. The principal component analysis could reduce those variables into a smaller number of principal components (the underlying dimensions) while those components still account for most of the variance in fourteen observed variables. The orthogonal rotation resulted in uncorrelated principal components and made interpretation of those components easier. The number of components was determined by a combination of four approaches – the eigenvalue-one criterion [10], the scree test [3], the proportion of variance accounted for [11], and the interpretability criterion [3].

In Stage 2, the survey instrument was tested for reliability and validity. The reliability reflects how well the observed scores collected by the survey instrument are related to the true scores [7]. As the true scores are unknown, the reliability of survey instrument is usually defined in practice in terms of the consistency of observed scores. Cronbach's α is one of the most widely used indexes of internal consistency reliability. It is mathematically equivalent to the average of all possible split-half estimates and serves as an upper-bound estimate of reliability [6]. The results of principal component analysis exhibit convergent validity, discriminant validity, and factorial validity [13].

In Stage 3, the average scores of items within each dimension (component) were calculated, and the bivariate correlations between the dimensions and the user's satisfaction were used to assess the marginal importance of each dimension for improvement of the Web-based course management system (WCMS). The marginal importance cannot be determined by simply asking users the extent to which each dimension is important in making them satisfied with the WCMS. There are at least two reasons for not obtaining scores of importance in this way. First, prior research on human judgment suggested that people were poor judges as to what information they thought and a statistical model such as correlation analysis was better [7]. Next, in order to improve the existing systems, marginal importance, measured by correlation coefficients, is more appropriate than scores of importance obtained by simply asking the above question. One example well explained difference between the marginal importance and the importance. If you ask travelers what is the most important for airlines to make them satisfied, the answer will be "safety." However, when buying a ticket, most travelers consider the price of ticket the most important variable. Among all variables, "safety" is the most important. However, given the current level of "safety" in airline industry, "price" is marginally more important than "safety." The purpose of this study is to improve the existing WCMS. Therefore, the bivariate correlations between the components and the user satisfaction were used to assess the marginal importance of each dimension.

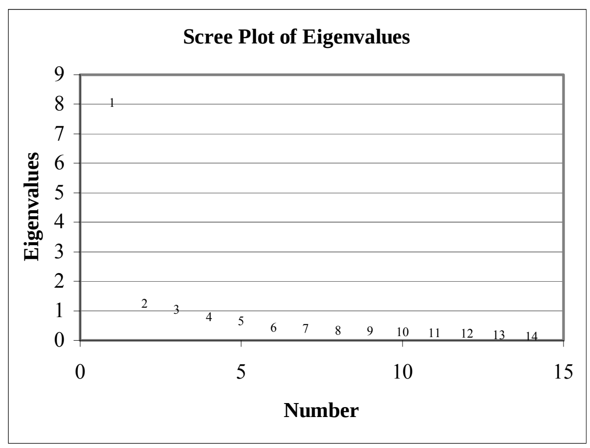
3. RESULTS AND DISCUSSION

The number of components initially extracted by the principal component analysis is equal to the number of the variables being analyzed. The result of initial extraction is shown in Table 1. The scree plot is shown in Figure 1.

Table 1. Eigenvalues of Principal Analysis

Variable	1	2	3	4	5	6	7
Eigenvalue	8.02	1.23	1.01	.76	.63	.42	.39
Variable	8	9	10	11	12	13	14
Eigenvalue	.30	.29	.25	.22	.21	.16	.11

Figure 1. Scree Plot of Eigenvalues



A combination of four approaches (the eigenvalue-one criterion, the scree test, the proportion of variance accounted for, and the interpretability criterion) was used in determining the number of components that should be retained. From Table 1, three components have eigenvalues greater than one and will be retained by the eigenvalue-one criterion. The scree test looks for a break between the components in terms of eigenvalues. In Figure 1, there is a break between the first two components and, therefore, one component will be retained by the scree test. The approach of "proportion of variance accounted for" retains a component if it accounts for a specified percentage of total variance in the variables being analyzed. This approach has been criticized for its arbitrary critical values [11]. The critical values usually used in practice were 10% for individual components and 70%-80% for the combined components [6]. In Table 1, the eigenvalues represent the amount of variance accounted for by each component. In the principal component analysis, the observed variables are standardized with a mean of zero and a variance of one and, therefore, the total variance in the fourteen variables being analyzed is fourteen. From Table 1, the first three components account for approximately 73% of the total variance while the first two components account for only 66%. It again suggests that three components will be retained.

The orthogonal rotation results in uncorrelated principal components and makes it easier to interpret those components. Table 2 shows the loadings on components and communalities of observed variables from the orthogonal rotation. The loadings are equivalent to the bivariate correlations between the observed variables and the components, and communality refers to the amount of variance in an observed variable that is accounted for by the retained components [6]. For variables V1 through V14, readers are referred to Appendix.

Table 2. Loadings and Final Communality Estimates from Orthogonal Rotation

	V1	V2	V3	V4	V5	V6	V7
Component 1	.22	.42	.19	.18	.39	.67	.38
Component 2	.64	.49	.25	.23	.59	.27	.68
Component 3	.29	.38	.84	.86	.39	.39	.33
Communality	.55	.58	.83	.84	.66	.69	.73
	V8	V9	V10	V11	V12	V13	V14
Component 1	.34	.21	.68	.68	.72	.82	.84
Component 2	.84	.87	.48	.49	.34	.13	.24
Component 3	.15	.17	.07	.17	.08	.29	.15
Communality	.85	.85	.71	.75	.65	.79	.80

Examples by Hatcher [6] suggested that an item loaded on a given component only if the loading of that item was 0.4 or greater for that component and was less than 0.4 for the other. An item should be dropped if it loaded on more than one component. Nunnally [13] recommended a stricter rule – "A common rule of thumb for assessing construct validity is that individual items should have a factor loading of at least 0.6 on their hypothesized construct (for convergent validity) and less than 0.3 loading on all other constructs (for discriminant validity)." Considering interpretability, this study used a combination of two rules - an item loaded on a given component only if the loading of that item was 0.6 or greater for that component and was less than 0.4 for the other. From Table 2, items 6, 12, 13, and 14 loaded on component 1. In the survey form (Appendix), questions 6, 12, 13, and 14 all seem to deal with "interaction among students and instructors", and component 1 was subsequently labeled the "interaction" component. Items 1, 7, 8, and 9 loaded on component 2. Questions 1, 7, 8, and 9 all seem to deal with "ease of use", and component 2 was subsequently labeled the "ease of use" component. Questions 3 and 4 loaded on component 3. Questions 3 and 4 seem to deal with "responsiveness of systems", and component 3 was subsequently labeled the "responsiveness" component. The interpretability criterion again suggests that three components should be retained. Combining all four approaches, this study identified three components (underlying dimensions).

The survey instrument was tested for reliability and validity. In this study, according to Nunnally [13], strong correlations between individual items and their components demonstrated convergent validity while relative weak correlation between individual items and other components demonstrated discriminant validity. Factorial validity assesses whether the survey items (observed variables) form distinct constructs. The principal component analysis showed that the retained items loaded on distinct constructs in terms of interpretation of components, which demonstrated factorial validity. The scale reliability was assessed by calculating Cronbach's α. Cronbach's α reliability estimates were 0.87, 0.89, and 0.85 for the interaction, ease of use, and responsiveness scales, respectively. Reliability estimates all exceeded the minimum value of 0.70 recommended by Nunnally [13]. In Table 2, communality refers to the amount of variance in an item that is accounted for by the retained components. After dropping items 2, 5, 10, and 11, the three components account for approximately 54% of the total variance in the fourteen variables being originally analyzed.

Finally, the average scores of items within each component were calculated, and then the bivariate correlation coefficients between the components and the user's satisfaction were used to assess the marginal importance of each component in improving the Web course management system (WCMS). The correlation coefficients and their p-values were shown in Table 3. All components were significantly correlated with user's satisfaction. The correlation coefficients of the first two components were roughly the same while the correlation coefficient of "responsiveness" was substantially lower. Those correlation coefficients indicated that dimensions of "interaction among students and instructors" and "ease of use" were more important in improving the existing WCMS.

Table 3. Correlations between Components and User's Satisfaction

	Interaction	Ease of Use	Responsiveness
Satisfaction	0.7044 $p<0.0001$	0.7388 $p<0.0001$	0.4418 $p<0.0001$

4. SUMMARY

This study applied the principal component analysis to questionnaire data. The analysis revealed three underlying dimensions - "interaction among students and instructors," "ease of use," and "responsiveness of systems." Those three scales demonstrated high convergent validity, discriminant validity. Further, correlation analysis indicated that dimensions of "interaction among students and instructors" and "ease of use" were more important in improving the WCMS.

Educational administrators will benefit from those insights by knowing on which of those dimensions they should apply the resources. The underlying dimensions and their marginal importance could extend knowledge of educational administrators and system developers beyond the mere responses to the items in the questionnaire. Interaction among students and instructors has been considered one of the most important components in traditional classroom teaching. As expected, the analysis revealed that component "interaction among students and instructors" was important in improving the WCMS. The component contained items 6 (instructor's help in chat room), 12 (online test), 13 (chat room improved course performance), and 14 (online test comments). While improvement could be made in terms of those items, administrators and developers might consider improvement in other respects of "interaction among students and instructors." As the analysis also revealed importance of component "ease of use," improvement of "ease of use" might be made beyond the limit of items 1 (easy to find information I need to improve course performance), 7 (perform the stated function perfectly), 8 (learn about the WCMS in a short amount of time), and 9 (the WCMS is easy to use). The component "responsiveness of systems," which contained items 3 (quick response to request for help with problem of system use) and 4 (quick response to request for a Web page), was considered relatively less important in improving the WCMS. At the current level of system quality, improvement of "responsiveness of systems" is expected to have less impact on user's satisfaction with the WCMS. In conclusion, educational administrators and system developers should apply resources on improvement of "interaction among students and instructors" and "ease of use" to increase user's satisfaction with the WCMS.

5. REFERENCES

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APPENDIX: SURVEY FORM

To better serve you, we would like to know your opinion of the quality of our Web Course Management System (WCMS) at Virginia State University. Please indicate the extent to which you agree or disagree with the following statements about the WCMS. Circle the appropriate number using the scale below. Some statements are similar to one another to ensure that we accurately determine your opinion concerning the WCMS.

1 – I strongly disagree with this statement (SD).
2 – I disagree with this statement (D).
3 – I neither agree nor disagree with this statement (N).
4 – I agree with this statement (A).
5 – I strongly agree with this statement (SA).

1. The information on Web pages contained what I needed to improve my course performance.
2. The information on Web pages was sufficiently detailed to help me understand the course subjects.
3. I waited a short period of time to get help when I had problem to use the system.
4. I waited a short period of time before a requested Web page showed up.
5. The instructor was quick to response when I sent him/her message through the WCMS.
6. The quality of way the instructor helped me in the "Chat room" was high.
7. The WCMS always perform the stated function perfectly.
8. I was able to learn about the WCMS in a short amount of time.
9. The WCMS was easy to use.
10. Online syllabus improved my course performance more than a paper-based syllabus.
11. Online course notes improved my course performance.
12. Online test was better than paper-based tests with respect to reflecting my knowledge of the course.
13. Chat room improved my course performance even through I could meet instructor in office.
14. Online comments on my tests help improve my course performance.
15. I am very satisfied with the WCMS.