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THE IMPACT OF TWO ESSENTIAL WEB SITE BUILDING COMPONENTS: THE EXPERIMENTAL STUDY ON THE HYPERLINK AND NODE

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Abstract

To investigate the impact of the usage of number of hyperlinks and node size in Web sites on users' perceptions, laboratory experiments were conducted using four versions of Web sites developed by the authors with undergraduate students at the University of Mississippi. Data were gathered through a post experiment questionnaire and post-test, and then analyzed and investigated for the impact of hyperlink and node on the efficacy of Web site designs. Principal components analysis followed by varimax rotations was conducted to evaluate factorial validity. Cronbach's alpha reliability coefficients were also computed to confirm the significant internal reliabilities among the measures. Population equality was checked by Levene test using pre-test scores. Multivariate analysis of variance (MANOVA) with follow-up univariate tests (two-way ANOVAs) was used to verify proposed hypotheses. Results of the study indicate that the hyperlink and node of the Web sites are very important to deliver more positive users' perceptions. This study found that Web site structure designed with many hyperlinks and small node size yields the most positive users' perceptions.

Keywords: Web site, hyperlink, node, perceived usefulness, perceived ease of use

Introduction

Advanced Information Technology (IT) makes corporations possible to compete to other competitors in this competitive global business environment. IT is a critical factor of today's business speed, consistency, and accuracy (Seen, 1998). Corporations use IT for their diverse purposes such as multimedia training, marketing, internal processing, external integration, and networking to enhance their compatibility (Webster and Ho, 1997; Huang and Windsor, 1998; Sharda, 1999). Among the most advanced IT, the Internet has become increasingly important to organizations that want to have some benefit from using the Internet commercially. Since the Internet was evolved from a U.S. Department of Defense network, the Internet was mainly used for scientific research for a while. Although large corporations used the Internet, they still limited the use of the Internet to their market and other engineering research. However, as Cronin (1995) stated, the number of commercial Internet users exceeded the number of research and educational Internet users by the fall of 1994. Since then, many manufacturing organizations have established Web sites to attract the potential buyers' attention, to sustain closer relationships with customers, and to do their business through the electronic store front. Others like Internet service organizations have built up portal services to provide easy access to the Web resources and set up search capabilities to help corporations capture prospective buyers.

There are ample evidences that suggest that the Internet can be used commercially and be effective and efficient in doing business through the Web site. There have been several researches that reveal some guidelines about manipulating media, colors, and designs. However, there are not many researches about how Web site should be structured. Although many corporations use Web

sites for their business actively, they have little known about how to develop the most efficient Web sites to maximize their profit (Hoffman and Novak, 1996). Companies who develop their commercial Web site still apply a traditional publishing technology and ignore the importance of interactivity and the nature of multimedia material. The lack of knowledge about how the Web site should be structured utilizing hyperlink and node, the essential components of any Web site organization lead us to study the effectiveness of the usage of the components.

The goal of this study is to investigate what kind of Web sites is more useful and easy to use for the users. For this study, we modified the framework to study the computer Recollection process developed by Bostrom et al. (1990) based on cognitive psychology (Norman, 1983) and educational psychology (Cronbach and Snow, 1977), information systems (Jagodzinski, 1983) and computer science (Brown and Newman, 1985). We developed a revised framework with these two essential components of Web sites: hyperlinks and node. We have analyzed four versions of Web site developed by us in the lab with 90 undergraduate students at the University of Mississippi. We collected the data by post-test and post experiment survey. The survey questionnaire developed included twelve question items adapted from Davis (1989) to measure the participants' perceived ease of use and perceived usefulness of the Web sites visited. The data collected were analyzed using SPSS package. Principal components analysis followed by varimax rotations was conducted to evaluate factorial validity. Cronbach's alpha reliability coefficients were also computed to confirm the significant internal reliabilities among the measures. Population equality was checked by Levene test using pre-test scores. Multivariate analysis of variance (MANOVA) with follow-up univariate tests (two-way ANOVAs) was used to verify proposed hypotheses.

Hyperlinks and Nodes in Web Sites

Hyperlinks, one of the basic building blocks of Web page, connect nodes and ideas. Hyperlinks can connect entities within and between nodes. This linking capability makes Web site a nonlinear organizational document. Hyperlinks can be used for several functions. They can connect a document reference to the document itself. They can connect a comment or annotation to the text or media about which it is written. They can provide organizational information. They can connect two successive pieces of text or any media. And they can connect entries in a table or figure to longer descriptions, or to other tables or figures. Although the essence of Web sites is its machine-supported linking, the nodes (pages) are another essential, organizational component of Web sites. A node or page expresses a single concept or an idea in a Web design. The most nodes of Web sites are much smaller than traditional documents and tend to be units that do not blend with their neighbors). Nodes in the Web sites can have any number of hyperlinks that are pointers to other nodes. (Conklin, 1987a; Conklin, 1987b).

Although there has been a proliferation of applications on Web sites, few researchers assessed critical role of the basic building blocks - hyperlinks and nodes - of Web sites for developing more efficient site. Many studies only stated the superiority of Web sites compared to other methods (Higgins and Boone, 1990; Marchionini, 1988), but did not suggest how to develop better Web sites. Although hyperlinks and nodes are not new concepts, only a few researchers studied about it. (Bieber et al., 1997; Nielsen, 2000; Snaprud and Kaindl, 1994). Few researchers explicitly discussed design issues utilizing a different number of hyperlinks and node sizes. Thus, this study intends to investigate the impact of different nodes sizes and numbers of hyperlinks in Web sites.

Research Framework

The research model of the study is formulated based on a research model for end-user training proposed by Bostrom, et al. (1990). Social Cognitive Theory that is proposed by Bandura (1986) is applied to explain an attitude construct in the model.

Prior Research Model

Bostrom et al. (1990) developed a framework to study the computer Recollection process that integrates research from cognitive psychology (Norman, 1983) and educational psychology (Cronbach and Snow, 1977), information systems (Jagodzinski, 1983) and computer science (Brown and Newman, 1985). The research model proposed by Bostrom et al. (1990) suggests that training outcomes (user attitudes and Recollection performance) are influenced by three important factors: characteristics of target system, training approaches, and trainee characteristics. The model has six constructs and nine relationships. Each construct of the model represents a researchable set of variables. Davis and Bostrom (1993) used a subset of this framework to study the impacts of specific types of target system and training approaches on Recollection performance and user perception of system.

Social Cognitive Theory

Social Cognitive Theory (Bandura, 1986) is a widely accepted and empirically validated model on testing individual behavior. A specific dimension of Social Cognitive Theory is relevant for this research. Bandura's conceptualization of the cognitive determinants of individual behavior is the dimension. Two forces are held to be the primary cognitive determinants of individual behavior and explain the attitude construct of the conceptual model.

The first set relates to outcomes. Individuals are more likely to undertake behavior they believe will result in valued outcomes than those that they do not see as having favorable consequences. Many information systems researchers have considered the outcome expectations (Davis, 1989; Davis et al., 1989; Lucas, 1978; Robey, 1979; Schewe, 1976). The second set of expectations encompasses what Bandura calls "self-efficacy," or beliefs about one's ability to perform particular behavior. Self-efficacy or perceived ease of use affects choices about which behavior to undertake and affects the mastery of the behavior.

Research Design and Hypotheses

The operational research model that guides this research is shown on Figure 1. The model includes four constructs. They are node sizes, number of hyperlinks, perceived ease of use (self-efficacy), and perceived usefulness (outcome expectation).

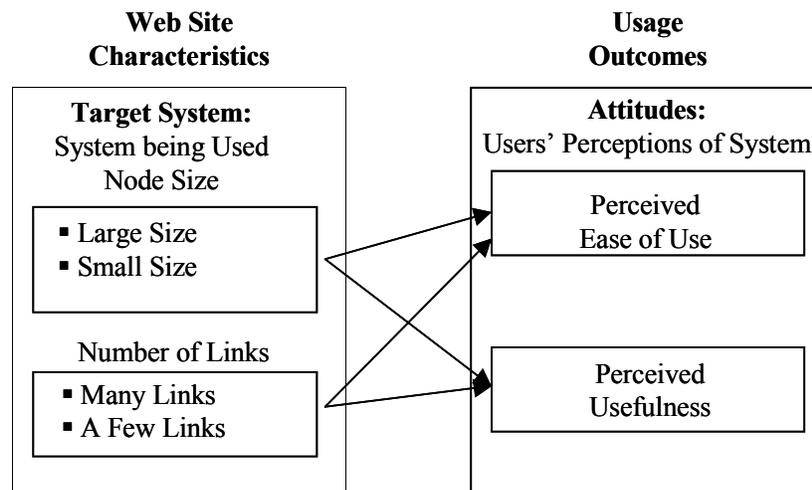


Figure 1. The Operational Research Model

Target System

Number of Hyperlinks

This study does not distinguish the type of link, because the type of hyperlinks may not be important in the Web sites. Hyperlinks connect the nodes and each type of hyperlink is created by the nature of the connections. By manipulating the number of hyperlinks, this research investigates their impact on users' perceptions. We pre-tested Web sites designed using different sets of hyperlinks with faculties and doctoral and master students. On the eight times of pre-tests, we used Web sites developed by using different numbers of links including from one to fifteen links. We gathered feedbacks from participants. The response to the Web site that had five to seven links were not clear. Some participants said the site had too small number of links, and some said too many. For the clear result of the experiment, we eliminated the number of links from five to seven. By these pre-tests, we set the number of "many" links to more than eight and "a few" links to less than four. We developed the experimental Web page using these figures.

Node Sizes

Although the essence of Web sites is its machine-supported linking, the node is another essential part of Web sites and is a basic building block. Nodes express a single concept or idea. Web sites nodes tend to be strict units that do not blend with its neighbor

pages. Developers can create Web sites involving any size of nodes. By manipulating the size of nodes, this research wants to investigate their effects - different size designs - on users' perceptions. We pre-tested Web sites designed using different set of node size with faculties and doctoral and master students. On the eight times of pre-tests, we used Web sites developed by using different number of monitor screens, node sizes, including from one to six monitor screens. We gathered feedbacks from participants. When the participants had more than three monitor screens, they already felt that the node is too long and should use scroll bar several times to reach the content below the first screen. By this pre-test, we set the 'large' size of nodes to more than three consecutive monitor screens and 'small' to less than or equal to two screens. We developed the experimental Web sites by this figures.

Perceived Ease Of Use

Perceived ease of use is a belief about one's ability to perform particular behavior. In other words, it refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). Social Cognitive Theory (Bandura, 1986) predicts that self-efficacy expectations will influence individuals' actual ability to perform the behavior. Studies in both clinical and organizational settings have demonstrated these effects on a variety of behavior, including sales performance (Barling and Beattie, 1983), and mathematics achievement (Schunk, 1981). Gist et al. (1989) also found a relationship between self-efficacy and performance in a computer training course. Davis (1989) claim that an application perceived to be easier to use than another is more likely to be accepted by the user, if all others are equal. Thus, this research is interested in which design of Web sites is high in self-efficacy. From constructs of the number of hyperlinks, node sizes, and perceived ease of use, hypotheses generated are as follows:

H1: *Different designs on the number of hyperlinks in the Web sites do not affect users' perceived ease of use.*

H2: *Different designs on node size in the Web sites do not affect users' perceived ease of use.*

H3: *Different designs on the number of hyperlinks and node size in the Web sites do not affect users' perceived ease of use.*

Perceived Usefulness

Perceived usefulness is "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989). Perceived usefulness has been considered by many information systems researchers (Compeau and Higgins, 1995; Davis, 1989; Davis et al., 1989). Social Cognitive Theory suggests that outcome expectations influence performance (Bandura, 1986). According to the theory, individuals are likely to undertake behavior they believe in. Individuals who expect positive outcomes from their use of the system exhibits higher performance than those who do not expect positive outcomes. Thus, this research is interested in which design of Web sites is high in perceived usefulness. From constructs of the number of hyperlinks, node sizes, and perceived usefulness, hypotheses generated are as follows:

H4: *Different designs on the number of hyperlinks in the Web sites do not affect users' perceived usefulness.*

H5: *Different designs on node size in the Web sites do not affect users' perceived usefulness.*

H6: *Different designs on the number of hyperlinks and node size in the Web sites do not affect users' perceived usefulness.*

Data Analysis

Data Collection and Questionnaire Measures

Ninety undergraduate students (58 male, 32 females) who are business major from three management courses volunteered to participate in the 100 minutes experiment. Four experimental sessions of around 20 subjects each were held in the microcomputer classroom. The average age of participants is 21.8 years old and average schooling year is 3.6 years. The average years of experience with computers are 3.44 years and experience with Web is 1.17. The post experiment questionnaire included twelve

items adapted from Davis (1989) to measure the participants' perceived ease of use and perceived usefulness of the Web sites. We adopted Davis' questionnaire that was developed and refined by using two studies. Seven-point Likert-type scales were used to measure each item. As a starting point of a data analysis, a factor analysis was conducted to check factorial validity (Bryman and Cramer, 1994). Then each variable was assessed for its internal reliability.

Validity

Factor analysis was conducted to assess the degree to which items were measuring the same concept. For the first step, a correlation matrix was computed for the twelve items and then correlations were examined because if there were no significant correlations among these items, they were unrelated to one another and the factors could not be formed. All but one of the items were significantly correlated at the $(\alpha)=.05$ level, which suggests that these items comprise the factors.

To examine this, principal components analysis followed by varimax rotations was carried on for all the twelve items. The results showed the presence of two factors whose eigenvalues were greater than one. Since the number of variables was less than 30 and all the communalities were greater than .70, Kaiser's rule (1960) was used. These two factors explained 77.8 percent of the total variance. The rotated factor matrix clearly revealed that factor one contained all the six of the perceived ease of use items and factor two comprised all the six of the perceived usefulness items.

Reliability

Internal reliability was examined to see whether each variable was measuring a single idea and to determine whether the items of a variable were internally consistent. This study employed the most widely used method for internal reliability estimation, Cronbach's alpha reliability coefficients. The results revealed that the alpha coefficient for the perceived usefulness was .93 and the score for the perceived ease of use was .95. Both scores were high enough to confirm the significant internal consistencies among the items, since the rule of thumb is that the calculated reliability coefficient should be .80 or above (Bryman and Cramer, 1994). The significant reliability coefficient scores and factorial validity analyses warranted conducting additional hypothesis tests using all six items for perceived usefulness (PUSEFUL) and the other six items for perceived ease of use (PEASEUSE).

Data Analysis

Laboratory experiments were conducted using a 2x2 factorial design to study the six proposed hypotheses. In the 2x2 factorial design, the treatment variables were two hyperlink numbers and node sizes of Web sites. In this study, the assumption that all the treatment groups come from populations with equal variances was controlled by random assignment of each participant to the different versions of the Web sites. To evaluate this assumption, the research used the Levene test that could be obtained with the one-way ANOVA procedure, since it was robust to departures from normality. The results of Levene tests confirmed the fact that all the treatment groups came from equal-variance populations, since observed significant levels were large enough (.833 for link number and .647 for node size).

With the Leven tests, a one-way ANOVA on the pretest for each treatment was computed to see the difference of participants' prior knowledge. The results showed that the difference of the participants' prior knowledge was not statistically significant ($p=.89>.05$ for link number and $p=.99>.05$ for node size). Besides the participants' self-reported measures of perceived usefulness and perceived ease of use stated earlier, demographic data were collected. The scales included seven items that were assessed using an open, fill-out form. Demographic analysis was conducted for these items. The average age of the subjects for this research was 21.77. The average years of college were 3.6 years. The participants had an average 3.44 years of overall computer experience and 1.17 years of Web sites experience.

A correlation analysis of the dependent variables was conducted to see whether these variables are significantly correlated. Bivariate correlations discovered that a dependent variable PUSEFUL was significantly correlated ($p=.000<.05$) with another dependent measure PEASEUSE. Full multivariate analysis of variance (MANOVA) was used as a starting point to evaluate the dependent variables with follow-up univariate tests, because MANOVA gives a more accurate assessment of the true efficacy of the treatments when the correlations exist among the dependent measures. Univariate analyses (two-way ANOVA) were performed on separate dependent variables.

The correlations between the dependent variables and the demographic variables were computed. SEX ($p=.021<.05$) and overall computer experience (COMEXP, $p=.003<.05$) were significantly correlated with Perceived Ease of Use (PEASEUSE). Therefore,

SEX and COMEXP were included as covariates in the multivariate analysis of covariance (MANCOVA) and analysis of covariance (ANCOVA).

Results

MANOVA And ANOVA Tests

Table 1 presents the results of the full MANOVA tests and two-way ANOVA tests. The results of the MANOVA shown in Table 1 indicate that both link number ($p=.036<.05$, $F=3.04$) and node size ($p=.000<.05$, $F=10.19$) effects are significant at the .05. The interaction effect ($p=.074<.10$, $F=2.45$) of these two treatments also significantly affects to the dependent variables at the level .10. The results of the subsequent univariate two-way ANOVA for each dependent variable reveal the attribute of these effects. The results indicate that only the node size ($p=.046<.10$) is significant for the perceived usefulness at the .05 and only the interaction effect is significant for the perceived ease of use at the .05.

Table 1. Summary of MANOVA and ANOVA Results

| MANOVA | | | | | |
|-----------------|---------|------------|----------|-------|--------|
| EFFECT | Exact F | Hypoth. DF | Error DF | P | |
| LINKNO | 3.04 | 3 | 82 | .36** | |
| NDSIZE | 10.19 | 3 | 82 | .000* | |
| LINKNO X NDSIZE | 2.45 | 3 | 82 | .074* | |
| ANOVA | | | | | |
| PUSEFUL | SS | DF | MS | F | P |
| LINKNO | 2.82 | 1 | 2.82 | 1.96 | .167 |
| NDSIZE | 6.02 | 1 | 6.02 | 4.18 | .046** |
| LINKNO X NDSIZE | .27 | 1 | .27 | .19 | .669 |
| PEASEUSE | SS | DF | MS | F | P |
| LINKNO | .15 | 1 | .15 | .14 | .712 |
| NDSIZE | 2.54 | 1 | 2.54 | 2.32 | .133 |
| LINKNO X NDSIZE | 7.12 | 1 | 7.12 | 6.52 | .013** |

** $p<.05$, * $p<.1$

MANCOVA and ANCOVA Tests

Table 2 shows the results of the full MANCOVA and Table 3 presents the results of the ANCOVA tests for the dependent measures, perceived ease of use. Table 2 indicates that the two covariates (SEX, and COMEXP) did not influence the results of the MANOVA tests. Subsequent univariate ANCOVA table for the perceived ease of use indicates that the covariates SEX ($p=.045<.05$) and COMEXP ($p=.000<.05$) have significant effects to the dependent variables, but again they do not change the result of the ANOVA test. Overall, both the MANCOVA and ANCOVA results explain that the two covariates do not influence on the users' perception of dependant variables.

Table 2. MANCOVA with SEX and COMEXP

| MANCOVA | | | | |
|---------------|---------|------------|----------|--------|
| EFFECT | Exact F | Hypoth. DF | Error DF | P |
| LINKNO | 2.19 | 3 | 78 | .43** |
| NDSIZE | 10.09 | 3 | 78 | .000** |
| LINKNOXNDSIZE | 2.43 | 3 | 78 | .078* |

** $p<.05$, * $p<.1$

Table 3. ANCOVA on Users' Perceived Ease of Use with SEX and COMEXP

| ANCOVA | | | | | |
|---------------|------|----|------|------|--------|
| PUSEFUL | SS | DF | MS | F | P |
| LINKNO | 2.82 | 1 | 2.82 | 1.96 | .167 |
| NDSIZE | 6.02 | 1 | 6.02 | 4.18 | .046** |
| LINKNOXNDSIZE | .27 | 1 | .27 | .19 | .669 |

** p<.05

Hypothesis Tests

Table 4 summarizes the outcomes of the hypotheses. Hypothesis H1, the effect of different designs of hyperlink numbers on users' perceived ease of use, can not be rejected ($p=.712>.05$, $F=.14$). Hypothesis H2, the effect of different designs of node size on users' perceived ease of use, could not be rejected ($p=.133>.05$, $F=2.32$). Hypothesis H3, the effect of interaction between two treatments on users' perceived ease of use, is rejected ($p=.013<.05$, $F=6.52$) at .05 significance level. Hypothesis H4, the effect of hyperlinks on users' perceived usefulness, can not be rejected ($p=.167<.05$, $F=1.96$). Hypothesis H5, the effect of node size on perceived usefulness, is rejected ($p=0.046<.05$, $F=4.18$) at the .05 significance level. The null hypothesis H6, the effect of the treatment interaction on perceived usefulness, can not be rejected ($p=.669>.05$, $F=.19$).

Table 4. Summary of Hypothesis Tests

| Hypotheses | p-Value |
|--|---------|
| Perceived Ease of Use | |
| H1: Different designs on the number of hyperlinks in the Web sites do not affect users' perceived ease of use. | .712 |
| H2: Different designs on node size in the Web sites do not affect users' perceived ease of use. | .133 |
| H3: Different designs on the number of hyperlinks and node size in the Web sites do not affect users' perceived ease of use. | .013** |
| Perceived Usefulness | |
| H4: Different designs on the number of hyperlinks in the Web sites do not affect users' perceived usefulness. | .167 |
| H5: Different designs on node size in the Web sites do not affect users' perceived usefulness. | .046** |
| H6: Different designs on the number of hyperlinks and node size in the Web sites do not affect users' perceived usefulness. | .669 |

** p<.05

Conclusion and Discussion

In this paper, the impact of the hyperlink number and node size on the several dependent variables is investigated in an experimental setting. Overall, the study results provide strong evidence that hyperlink number and node size in developing Web site are important factors to set up Web sites for more profit. Interestingly, users preferred to have sites involving small nodes and more links according to the descriptive analysis of mean difference.

For the perceived usefulness measure, only the node size has significant effects. This result suggests that node size is a more important factor for users to distinguish the usefulness of Web sites than others. When a node is too large expanding to several monitor screen pages, users are usually sick to scroll down. They may not go down to the bottom of nodes and leave the site when Web sites do not include many hyperlinks. When a node is too small, the node usually might not contain significant information in it, because it limits the physical space to put a unit of information on a node. In this case, users should jump from a node to another node too often.

For the perceived ease of use measure, each treatment alone does not significantly influence participants' perceptions of the ease of use. Only the interaction affects users' perception on the ease of use. This finding implies that users think Web sites are easy to use when the Web sites are developed with well-managed combinations of the two important Web building components.

Developers might set up larger nodes with many hyperlinks so that users do not lose their interest on the site or utilize many small-sized nodes with less number of hyperlinks to give users less confusion.

There were two covariates identified through the bivariate correlation analysis between demographic data and dependent measures. The two covariates were found significant for the perceived ease of use measure, but they do not change the results of the original variance analyses. This implies that the research results are consistent regardless demographic differences.

Like any other research paper, this study also has some limitations. This paper does not distinguish between the two kinds of hyperlinks, interlinks and intralinks and the type of hyperlink structure. This paper only uses the number of hyperlinks to give an idea about how many links should be used for better users' perceived usefulness and ease of use. We experimented in the educational setting, but if we can execute the same kind experiment in business organizational setting, the results can be more easily generalized. We involved a simple research model to explain the role of hyperlinks and node size. For the next research, more extended model should be employed.

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