Measurement of Informational Graphic and Sign Systems Design for University Libraries

Tzung-Hui Wang * and Szu-yu Tzeng **

** Graduate School of Design, National Yunlin University of Science and Technology, Taiwan*
wang626.philip@msa.hinet.net
*** National Yunlin University of Science and Technology, Taiwan*
tzengsy@yuntech.edu.tw

Abstract: Library graphic information and sign systems are a close visual and spatial link between users and libraries. In this paper we first define the following factors: location, content, color, font-style, lighting, size, form and material. Next, following questionnaire is based on related literature and scholarly interview results. We used the content validation, to generate the questions. Finally, confirmatory factor analysis was performed using the software application LISREL 8.72. The software was used to establish a sign system measuring model to test the validity and the values for the goodness-of-fit. The objective was to convert the developed scale into a result-oriented evaluation tool. The scale was formed by using the comprehensive evaluated index. Based on the formula of Bruhn and Grund, this study digitized the measurement model and calculated factors and overall Measurement Indices of different samples as the criteria to improve the sign system quality.

Key words: sign systems, university libraries, measurement modeling, confirmatory factor analysis.

1. Introduction

University libraries are the repositories of information for education, research, display and collection. Wayfinding and traffic patterns are critical when determining the quality and efficiency of a library service. Graphic and sign systems are probably the solution (Shyu, 1988). In the US, 75% to 80% of university students suffer from a library phobia because of the frustration at not being able to find the materials they need. The phobia is due to the lack of facility directions, and unpleasant experiences when seeking assistance (Mellon, 1986). In the article Wayfinding in Library: A Case Study of Taipei Municipal Library Users, Hou (2001) outlines the environmental factors that influence wayfinding (see Table 1).

Table 1 The Environmental Factors that Influence Wayfinding in Library

Environmental Factors	Sign systems	Spatial layout	Plan	Library facilities
Beck (1996)	v		v	
Webster (1998)	v	v	v	
MacMinner (2000)	v	v	v	
Tzeng (1996)	v	v	v	v
Chen (1999)	v	v	v	
Lee (2001)	v	v		

While designing sign systems, many designers usually overemphasize the visual effect and neglect their aim which is to convey the information of graphic and sign systems. The paradigm that artistic workers should design the graphic and sign information should be abandoned, as Maquet (2003) argues.

This study digitized the measurement model and calculated factors and overall measurement indices from different samples to establish criteria to improve the sign system quality. The analysis includes the following:

1. By collecting informational graphic and sign systems literature and conducting in-depth interviews, we established a way of measuring factors for sign systems.
2. We used Confirmatory Factor Analysis (CFA) to establish a sign systems measuring model to test its validity and the values for the goodness-of-fit.
3. We converted the developed scale into a results-oriented evaluation tool. This study digitized the measurement model and calculated factors as the criteria to improve the service quality of libraries.

2. Literature review

2.1 Wayfinding

Wayfinding is a complicated task of cognition (Evans et al., 1980). Environmental behaviorist Down (1979) points out wayfinding is used to solve spatial movement problems occurring in a process of cognition. Wayfinding means identifying objects' locations and paths in a space, including environment cognition and transformation of environmental information into decisions and actions (Authar and Passini, 1992). Wayfinding is absolutely necessary in today's society (MacMinner, 1996). The three factors that affect wayfinding are: (1) Personal factors including physical characteristics such as sight, hearing and time to react; psychological factors such as motives, understanding, familiarity, emotion, intelligence, and individual difference. (2) Environmental factors including the complexity of the space and too many main gates. (3) Graphic and sign systems including their design content, locations and numbers (Huang, 2003).

2.2 Sign Systems

According to American Institute of Graphic Arts (AIGA), signs are defined as the visual design to provide identification, explanation and warning by means of the combination of words, figures and colors. The basic elements of design systems (R&D Committee of the Executive Yuan of the ROC, 2005) are described as follows:

1. Pictogram designing - Sign systems designing is based on dots, lines, surfaces and cubes. Pictograms are symbols of colors and figures. The designing principles are (1) standardization, (2) consistency, (3) simplicity, (4) visibility and clear communication, (5) compatibility.
2. Lettering designing - Legibility is one of the major points in lettering designing.
3. Color designing - Safe colors in many countries have specific meanings. These safe colors have almost become the internationally recognized color language.
4. Design rules - (1) a limited number of graphic and signs, (2) regulated sign locations, (3) unified sign forms and (4) unified graphic and sign systems in each space or area.

2.3 Library sign systems

Bosman and Carol (1997) proposed these factors friendly libraries should possess which include easy and concise sign systems. A well-designed sign system should be able to display all the services in the library and also give the users an inner map to understand exactly where they are located (Selfride, 1979). When designing sign systems in school libraries, keep in mind the following points (Daniel, 1979): (1) Sign systems should be dynamic. Sign systems change with plans; some are permanent whereas others are temporary. (2) There should be uniformity in sign systems, e.g. the same font using different sizes. (3) Sign systems can be categorized into main sign systems and subordinate sign systems. (4) Each sign should only indicate the information needed on that exact spot. (5) Sign systems should be explicit. (6) Any appropriate surfaces can be used for sign systems, for example, floors, walls and ceilings. (7) Due to the spatial limitations, certain signs, good but not required, might be removed to avoid visual confusion.

2.4 Summary

The research summarizes the principles of sign systems for libraries:

1. Location - The major points of locations are: (1) For wayfinding, the best location for signs system is the "main gate" where people make decisions. (2) Directional signs should be vertical with users' direction or halls. (3) Signs should be able to be clearly identified. (4) The height of signs should not higher than human view line 20 degrees. (5) The consistency of sign locations should make it easy for users' to find their destinations.
2. Contents - The major points of contents are: (1) An appropriate combination of words and symbols that clearly transmits the correct information. (2) Enable users to quickly scan signs for the location information. (3) Not all users understand the terms used in the signs. (4) Avoid using negative words, repetitive words or synonyms. (5) Each sign (direction or location) should display one step, not all of them. (6) When the sign is located at a corner, the lighting must be sufficient, (7) Signs should always be concise.
3. Color - The major points of coloring design are: (1) Consider the interior color of the library. (2) Pay close attention to the contrast between the colors of letters and signs. (3) Directional Signage should be easily seen from a long distance. Choose bright colors to catch viewers' attention. (4) Ceiling signs' colors shouldn't be the same as the color of the ceiling.
4. Font-style - The major points of lettering design are: (1) When the lighting is not sufficient, letters on sign systems should be enlarged. (2) Bold type is for important messages. (3) The fonts should match up with the interior design style.
5. Lighting - The major points of lighting designing are: (1) Appropriate lighting conditions can make letters on signs look bigger. (2) The contents of sign systems, environmental conditions and the relationship to viewers have to taken into consideration.
6. Size - The size of sign systems depends on the contents, the words, and the viewing distance.
7. Shapes and forms - The shapes and forms of sign systems have to be systematic.
8. Material - Take into consideration the following factors: purpose, contents, environmental conditions, costs, as well as maintenance and replacement.

3. Research Design

Based on related literature, in-depth interviews with library scholars, and the information collected in the research, we carefully created and selected the items that would make a measure. Three experts in spatial design who have some knowledge of the sign systems were asked to review the selected items, and to provide modified opinions. We discarded or rewrote unclear items or items on which there were disagreements between experts.

We developed an initial 35-item pool of the questionnaire: (1) Location with 7 items, (2) Content with 6 items, (3) Color with 5 items, (4) Font-style with 4 items, (5) Lighting with 4 items, (6) Size with 3 items, (7) Shapes and forms with 3 items and (8) Material with 3 items. Then the research conducted a pilot study to ensure content validity.

The measurement of this research was based on the 6-point Likert scale. The scale of even numbers was used because we expected each participant to properly express the intensity of their psychological perception. This research adopted purposive sampling to conduct a pilot study on the measurement tools. A sample of 181 individuals was collected through design related courses from two universities and a university of technology. The valid sample corresponded with the ratio of measurement items to the number of pilot study participants 1:5 (Tinsley and Tinsley, 1987). The research performed both Items Analysis and Exploratory Factory Analysis to examine the sample for reliability and validity.

We arranged the total scores of the pilot study in order by internal consistency and treated the gap between 25% of higher scores and 25% of lower scores as the discriminatory power of the items. The values of the discriminatory power ranged from 1.31~2.66; and the critical ratio ranged from 12.901~23.573, reaching at the 0.05 level of significance. The results indicated that the 35 items on the measured scale were satisfactory and served as the items for further exploration.

The paper conducted the first time factor analysis with the 35 items. The five items Size 3, Content 3, Content 6, Material 3, and Location 3 were excluded. We conducted the second time factor analysis with 30 items. Content 1 was excluded. Then we conducted the third time factor analysis with 29 items. Color 3 was excluded. Finally, the 28 item measure was for analysis, as shown in Table 2.

According to the result of the factor analysis, the KMO value was 0.968 and reached the significance level. That indicated that common factors existed in the correlation matrix of the population and was suitable for further factor analysis. The research calculated the reliability of each item. The overall Cronbach's α was 0.961, Cronbach's α for Factor 1 (9 items) was 0.930; Factor 2 (9 items) was 0.897; Factor3 (6 items) was 0.893 and Factor 4 (4 items) was 0.793. The above factors met the requirement of Nunnally and Berstein (1994) that Cronbach's α in more convincing or mature studies the value should be at least greater than 0.7.

In the study of social science, the common factors should explain at least 60% of total variance of the observed variables (Hair Jr. et al., 2006). Four constructs in this research could explain 62.884% (>60%) of total variance of 28 items. According to the result of the factor analysis, four constructs were named below: Factor 1 "Layout aesthetics"; Factor 2 "Display functions"; Factor 3 "Systematic consistency"; and Factor 4 "Environmental lighting".

4. Data analysis

The method employed in this research is referred to as "convenience sampling". A sample of 450 individuals is the population for the questionnaire. The population was collected from a public university, a private university and a public technology university in Taiwan. We asked 450 university students to fill out the questionnaires. 408 copies of the questionnaires were returned and among them 380 copies were valid questionnaires (the valid ratio was 84.44%).

Table 2 Rotated Component Matrix after the Final Factor Analysis

	Reduced Set of 28 Variables	Varimax-Rotated Loadings			
		Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	Color 1	0.829			
	Color 2	0.799			
	Color 5	0.751			
	Form 1	0.690			
	Font-style 3	0.666			
	Color 4	0.665			
	Material 2	0.644			
	Font-style 4	0.583			
	Content 5	0.576			
Factor 2	Location 2		0.713		
	Location 1		0.658		
	Location 4		0.656		
	Content 1		0.637		
	Location 6		0.623		
	Location 7		0.621		
	Location 5		0.585		
	Content 2		0.549		
	Content 4		0.540		
Factor 3	Font-style 2			0.676	
	Form 2			0.664	
	Font-style 1			0.590	
	Form 3			0.573	
	Size 2			0.564	
	Size 1			0.557	
Factor 4	Lighting 3				0.780
	Lighting 2				0.731
	Lighting 4				0.619
	Lighting 1				0.514
Sum of Squares (Eigenvalues)		6.354	4.857	3.651	2.746
% of Variance		22.694	17.346	13.038	9.805
Cumulative %		22.694	40.041	53.078	62.884

4.1 Hypothesized model

Confirmatory Factor Analysis (CFA) describes and estimates the factor framework of one or several hypothetical models. Generally speaking, there is only the measurement model in Confirmatory Factor Analysis but no structural model. In the second-order CFA model, there is a linear relationship between first-order and second-order latent variables (Doll et al., 1995). In other words, when the researchers apply second-order or more advanced CFA, we can still determine the structural model. This research thus constructed four models (three first-order CFA and one second-order CFA), as below: (1) Model 1: first-order one factor model, (2) Model 2: first-order multiple factor orthogonal model, (3) Model 3: first-order multiple factor oblique model and (4) Model 4: second-order factor model.

4.2 Model fit

Several "goodness-of-fit indices" are commonly used to evaluate how well the structural model fits the data. In this research Confirmatory Maximum Likelihood Factory Analysis was used to test "the goodness of fit" of the four models. The chi square goodness-of-fit test is one of the most commonly used indices. If the ratio of chi-square to degree of freedom ($\chi 2/df$) is < 3.0, then it means the model fit is adequate (Carmines and Mclver, 1981). As shown in Table 3, the fit indices for Model Four was adequate; the ratio of chi-square to degree of freedom ($\chi 2/df$) was 2.537 (df=346) < 3.0, which means the model fit is adequate.

Marten (2005) recommended using RMSEA and CFI as the primary goodness-of-fit indexes. For RMSEA, a value of 0.08 is the acceptable threshold (McDonald and Ho, 2002; Browne and Cudeck, 1993). In our research, the RMSEA value was 0.064, less than 0.08, which indicated the hypothetical model has a reasonable fit with the data. Comparative Fit Index (CFI= 0.98), Incremental Fit Index (IFI=0.98), and Relative Fit Index (RFI=0.91) all the indices reflected the theoretical model (model 4) and the observed data established in the research were well fitted.

Finally, regarding the conciseness of Model 4, the Parsimony Normed Fit Index (PNFI = 0.89), the Parsimony Goodness of Fit Index (PGFI = 0.73), both were > 0.50. The consistent Akaike information criterion (CAIC= 1294.06) was less than Saturated CAIC (2817.71) and Independence CAIC (30717.78). That indicated Model 4 established in the research was concise.

Table 3 Fit Indices for Competing Models of the Structure

	Hypothesized Models (Competing Models)	$\chi 2$ (df)	$\chi 2/df$	CFI	IFI	GFI	AGFI	RMSEA
Model 1	One-factor structure	2151.92 (350)	6.148	0.96	0.96	0.71	0.67	0.117
Model 2	Uncorrelated four-factor first-order model	1794.22 (350)	5.126	0.95	0.95	0.75	0.71	0.104
Model 3	Correlated four-factor first-order model	873.31 (344)	2.539	0.98	0.98	0.86	0.83	0.064
Model 4	Second-factor structure	877.65 (346)	2.537	0.98	0.98	0.86	0.83	0.064
The suggested values			< 3.0	> 0.9	> 0.9	> 0.8	> 0.8	< 0.08

4.3 Model structure analysis

1. The individual item reliability estimates latent variables factor loadings for measure variables. Factor loadings should be > 0.6 and also statistically significant. As shown in Table 4, factor loadings for each observed variables were in the range of 0.61~0.87 (> 0.6), thus having statistical significance. The composite reliability (CR) of latent variables is comprised of the reliability of all measure variables. Higher CR values indicate higher consistency among the measure variables. Fornell and Larcker (1981) suggested that the CR values of the variables in the research should be > 0.6. The coefficients of the samples in this research were in the range of 0.808~0.928 which indicated very good internal consistency for all individual items.

2. Variance Extracted (VE) of latent variables calculates the variance explanatory power of the latent variables for each measurement variable of latent variables. When Variance Extracted (VE) value is higher, that means more reliability and convergence validity of latent variables. Fornell and Larcker (1981) suggested that the VE value should be > 0.5, as shown in Table 4. The VE value of the Factor Display functions was 0.492, and the VE values of the remaining three factors were all in the range of 0.515~0.590 (> 0.5). All met the suggested values. Based on the above-mentioned indexes, the goodness-of-fit of the design measure framework was statistically significant as shown in Figure 1.

Table 4 Measurement Modeling Standardized Parameter

Factor		Item Loading	Standard Residual	R^2	Factor Loading	Composite Reliability (CR > 0.6)	Variance Extracted (VE > 0.5)
Layout aesthetics	C1	0.87	0.25	0.75	0.870	0.928	0.590
	C2	0.81	0.35	0.65			
	C3	0.81	0.34	0.66			
	C4	0.79	0.38	0.62			
	C5	0.78	0.40	0.60			
	C6	0.79	0.38	0.62			
	C7	0.66	0.57	0.43			
	C8	0.72	0.49	0.51			
	C9	0.67	0.55	0.45			
Display functions	C10	0.66	0.56	0.44	0.870	0.897	0.492
	C11	0.69	0.52	0.48			
	C12	0.71	0.50	0.50			
	C13	0.74	0.45	0.55			
	C14	0.70	0.51	0.49			
	C15	0.73	0.47	0.53			
	C16	0.67	0.55	0.45			
	C17	0.71	0.50	0.50			
	C18	0.70	0.51	0.49			
Systematic consistency	C19	0.68	0.53	0.47	0.960	0.892	0.580
	C20	0.74	0.45	0.55			
	C21	0.83	0.32	0.68			
	C22	0.73	0.47	0.53			
	C23	0.75	0.44	0.56			
	C24	0.83	0.31	0.69			
Environmental lighting	C25	0.76	0.42	0.58	0.800	0.808	0.515
	C26	0.74	0.46	0.54			
	C27	0.75	0.43	0.57			
	C28	0.61	0.63	0.37			

4.4 Pragmatic application

According to Bruhn & Grund (2000) and Bruhn (2003), this research digitalized measurement modeling and the sign system measurement indexes were shown in Table 5.

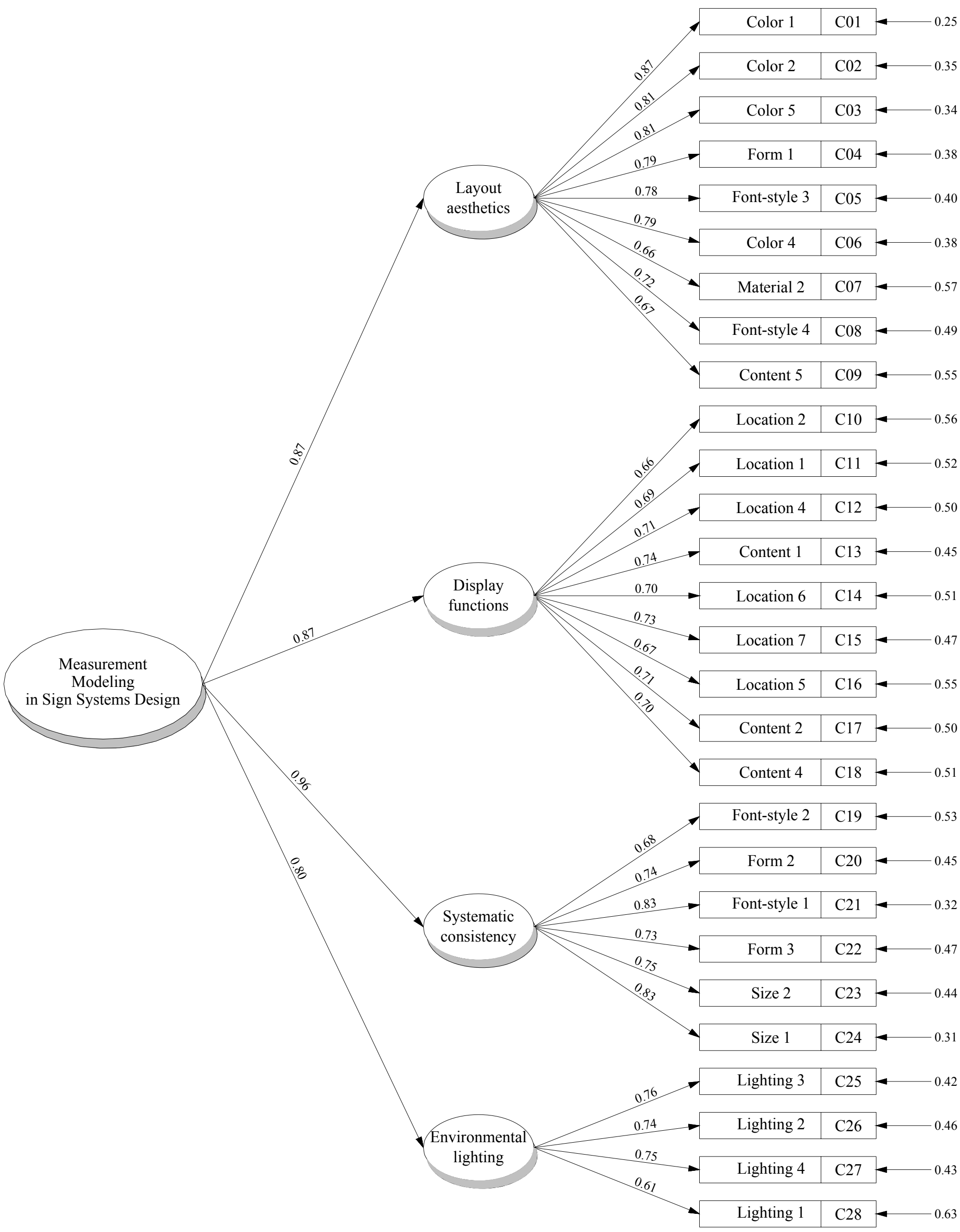

Figure 1 Measurement Modeling in Graphic and Sign Systems Design for University Libraries

Table 5 The Graphic and Sign Systems Measurement Indexes

Factor	Case A		Case B		Case C	
	Factor	Overall	Factor	Overall	Factor	Overall
Layout aesthetics	67.012	73.491	69.730	76.023	95.919	96.583
Display functions	76.089		79.217		95.880	
Systematic consistency	76.618		77.035		97.395	
Environmental lighting	73.986		78.161		97.084	

5. Conclusions

University libraries are an essential information source. It is imperative for users and librarians to be able to easily and quickly access the information they need. Library graphic information and sign systems are one of the best informational cues for users and librarians in university libraries. The research used the qualitative method and found 35 design elements that were likely to affect library sign systems. We grouped them into 8 categories. For those 35 items we performed both item analysis and exploratory factor analysis, we obtained 28 measure items which are of significant influence.

Confirmatory Factor Analysis was performed using the software application LISREL 8.72. The software was used to establish a sign system attribute measuring the model to test the validity and the values for the goodness-of-fit. In the research we found that the four factors (including 28 measure items) affecting the sign systems were: (1) Layout aesthetics; (2) Display functions; (3) Systematic consistency; (4) Environmental lighting.

There are complicated and related latent factors in Sign systems. Every user has their own yardstick. Through measuring indexes of factors, the advantages and disadvantages of each factor can be assessed and thus improve the service quality of libraries. This research provides an effective measuring tool of library sign systems design, from the prospective of library users. The measurement modeling we constructed hopefully can serve as a constructive reference for professionals in sign system design and academicians in further studies. On the other hand, the measurement modeling in the research can be used for long term follow-ups for users' requirements, and for implementation when library interior partitions are redesigned. However, due to time constraints, sign systems for barrier free environments were excluded in the research.

Acknowledgment

We would like to thank Dr. Ko-li Chen (Professor in the Department of Architecture, Tunghai University Taiwan) for his invaluable opinions and suggestions for writing questionnaire questions.

References

[1] Shyu, J. F. (1988) Signs and the School Media Center, *Social Education Bimonthly*, vol. 26, pp 48-51.

[2] Mellon, C. A. (1986) Library Anxiety: A Grounded Theory and Its Development, *College and Research Libraries*, vol. 47, no. 3, pp 162.

[3] Hou, H. L. (2001) *Wayfinding in Library: A Case Study of Taipei Municipal Library*, Master's thesis, Department and Graduate Institute of Library and Information Science, National Taiwan University.

[4] Maquet, J. (2003) *Aesthetic Experience: An Anthropologist Looks at the Visual Arts*, Hsiung-Shih Art Book.

[5] Evans, G. W., Fellons, J., Zorn, M. and Doty, K. (1980) Cognitive Mapping and Architecture, *Journal of Applied Psychology*, vol. 65, pp 474-478.

[6] Downs, R. M. (1979) *Mazes, minds and maps, in Sign Systems for Libraries*, New York: R. R. Bowker Co., pp 17-32.

[7] Arthur, P. and Passini, R. (1992) *Wayfinding: People, Signs, and Architecture*, McGraw-Hill Ryerson Limited.

[8] MacMinner, S. (1996) *Wayfinding: Human Perceptions & Orientation; in the Built Environment*, Online Internet, http://www.unl.edu:80/casetudy/456/sharon.htm.

[9] Huang, H. H. (2003) *A Study of Establishing the Evaluation Framework of Wayfinding Design for MRT Stations*, Master's thesis, Department of Transportation & Management, National Chiao Tung University.

[10] The Research, Development and Evaluation Commission, Executive Yuan (2005) *The Reference Guidelines of Designing Popular Pictograms for Public Signs*, Taipei.

[11] Bosman, E. and Carol, R. (1997) Creating the User-friendly Library by Evaluating Patron Perceptions of Signage, *Reference Service Review*, vol. 25, no. l, pp 71-82.

[12] Selfride, K. M. (1979) Planning Library Signage Systems, In Pollet, D. and HaskelI, P. (eds.) *Sign Systems for Libraries*, New York: Bowker, pp 49-67.

[13] Daniel, E. H. (1979) Signs and the School Media Center, In Pollet, D. and HaskelI, P. (eds.) *Sign Systems for Libraries*, New York: Bowker, pp 127-135.

[14] Tinsley, H. E. A. and Tinsley, D. J. (1987) Uses of factor analysis in counseling psychology research, *Journal of Counseling Psychology*, vol. 34, pp 414-424.

[15] Nunnally, J. C. and Berstein, I. H. (1994) *Psychometric theory*, New York: McGraw-Hill.

[16] Hair Jr., J. F., Black, W. C., Babin, B. J., Anderson, R. E. and Tatham, R. L. (2006) *Multivariate data analysis*, sixth edition, Upper Saddle River, NJ: Pearson.

[17] Doll, W. J., Raghunathan, T. S., Lim, J. S. and Gupta, Y. P. (1995) A Confirmatory Factor Analysis of the User Information Satisfaction Instrument, *Information Systems Research*, vol. 6, no. 2, pp 177-189.

[18] Carmines, E.G. and Mclver, J.P. (1981) Analyzing models with observable variables, In G. W. Bohrnstedt and E. F. Borgatta, *Social Measurement: Current Issues*, Beverly Hills: Sage.

[19] Martens, M. P. (2005) The use of structural equation modeling in counseling psychology research, *Counseling Psychologist*, vol. 33, pp 269-298.

[20] McDonald, R. P. and Ho, M. R. (2002) Principles and practice in reporting structural equation analysises, *Psychological Methods*, vol. 7, no. 1, pp 64-82.

[21] Browne, M. W. and Cudeck, R. (1993) Alternative ways of assessing model fit. In K. A. Bollen and J. S. Long (Eds.), *Testing structural equation models* (pp. 136-162), Newsbury Park, CA: Sage.

[22] Fornell, C. and Larcker, D. F. (1981) Evaluating Structural Equation Models with Unobservable and Measurement Errors, *Journal of Marketing Research*, vol. 18, pp 39-50.

[23] Bruhn, M. and Grund, M. A. (2000) Theory Development and Implementation of National Customer Satisfaction Indices: The Swiss Index of Customer Satisfaction (SWICS), *Total Quality Management*, vol. 11, no. 7, pp 1017-1028.

[24] Bruhn, M. (2003) *Relationship Marketing Management of Customer Relationships*, England Pearson Education Limited.