Web 2.0 Based on Covariance Structural Equation Modeling

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Abstract

From a user perspective, establish a Web 2.0 user mental model based on structural equation modeling to explore library users' attitudes, behaviors, and cognition in the Web 2.0 environment. Through quantitative methods and surveys, generate a theoretical foundation to serve as a framework for depicting new user knowledge services in the new network environment. Mental models can be utilized to create and use personas.

Full Text

A Mental Model of Web 2.0 Users Based on Covariance Structure Equation Modeling

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Abstract: From the user perspective, this study establishes a Web 2.0 user mental model based on structural equation modeling to explore library users' attitudes, behaviors, and cognition in the Web 2.0 environment. Through quantitative methods and surveys, a theoretical foundation is generated to serve as a framework for depicting new user knowledge services in the new network environment. Mental models can be used to create and utilize personas.

Keywords: Web 2.0; Library 2.0; user behavior; structural equation model; mental model
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1 Introduction

Many programmers are keen to "show off" technology, yet ordinary users often do not know how to use it. In fact, this is mostly due to poor product design rather than technological or training issues; adopting more "new" technologies cannot "solve" users' "dilemmas" [1].

The key lies in design, not technology. While adopting the latest technology serves as an auxiliary means to improve service quality, serving users is the ultimate goal of digital libraries. Understanding user psychology, behavior, and interaction habits is essential. To unlock the "black box" of user behavior, new methods need to be developed or existing tools introduced.

Mental models are patterns through which humans understand complex systems. From a manager' s perspective (similar to librarians), mental models are considered knowledge about the system being controlled [4], i.e., a "theoretical structure" [5] or a special kind of computer program [6]. From the perspective of the managed (similar to library patrons), mental models are considered psychological processes that individuals rely on when making decisions [7-8], or what Japanese economist Masahiko Aoki views as an individual' s programmed decision-making or cognitive processes [9]. This study adopts the user perspective—that of the managed—to conduct exploratory research on library users' attitudes, behaviors, and cognition in the Web 2.0 environment.

Such research requires finding appropriate methods from psychometrics to address "human behavior" issues in psychology, economics, sociology, and even library and information science. Covariance Structure Equation Modeling (SEM, also known as structural equation modeling) is precisely such a tool suitable for studying user mental models. It originated from Karl Jöreskog' s concept and LISREL software in Switzerland in 1973. The *Annual Review of Psychology* featured SEM prominently in both 1996 and 2000; today, every volume of *Psychological Methods* from the American Psychological Association includes papers on SEM [10]. After more than 30 years of development, structural equation modeling has reached maturity, with related software emerging rapidly, such as EQS (1985), CALIS (1992), RAMONA (1994), AMOS (1997), and Mplus (1998). The statistical software SPSS finally added the AMOS module in its 15th version in 2007. Since November 2007, the Journal of the American Society for Information Science and Technology (published by the American Library Association) has featured SEM-related papers in nearly every issue, underscoring its importance. However, there have been few survey studies on SEM in the domestic library and information science field in China.

As Web 2.0 evolves, user behavior requires continuous tracking and in-depth understanding [11]. Building upon previous survey experience, investigating new problems, perspectives, and methods holds practical significance for developing interactive design in digital libraries. Below, the author discusses ten commonly used network services, examining the interactive relationships among user attitudes, usage, and cognition, and employs covariance structure equation

modeling to establish a mental model.

2 Research Design

2.1 Survey Research Questions

The study examines whether structural relationships exist among users' preference levels, usage habits, and academic activity observations regarding Email, BBS, Chat Room, IM, Blog, P2P, RSS, SNS, Tag, and Podcast across 30 measurement items. Structural relationships encompass factor points and relationship lines. The questionnaire covers three aspects: preference levels for network tools, usage frequency of network tools, and whether network tools have academic utility.

2.2 Data Analysis Tools

Excel was used for data entry and preliminary scanning, followed by SPSS (Version 14) for data analysis.

2.3 Survey Subjects

Research subjects: Doctoral and master' s students of the Chinese Academy of Sciences (CAS). Sampling frame: Doctoral and master' s students enrolled in Beijing area CAS institutions in the second semester of 2008. Sample: Individuals who completed and returned valid questionnaires.

2.4 Questionnaire Design

The questionnaire contained 82 items; the first 36 items were analyzed, including data on personal information, attitudes toward network services, behaviors, and cognition.

2.5 Data Collection

A stratified random sampling survey was conducted through mailed questionnaires distributed and collected from June 9, 2008, to July 20, 2008. A total of 3,000 questionnaires were distributed, with 501 valid returns and 4 invalid questionnaires.

3 Results

3.1 Basic Data

3.1.1 Birth Year Distribution of Research Population According to data on graduate students in the Beijing area provided by the Graduate School of the Chinese Academy of Sciences, the average birth year was 1980.88 (SD = 4.358, skewness = -4.716, kurtosis = 63.050). Based on the skewness and

kurtosis values, the distribution can be characterized as negatively skewed (right-skewed) with higher kurtosis than a normal distribution.

3.1.2 Birth Year Distribution of Sample After questionnaire collection, the sample showed an average birth year of 1981.77 (SD = 2.778, skewness = -1.701, kurtosis = 4.168). The distribution was also negatively skewed (right-skewed) with higher kurtosis than a normal distribution. Notably, both the sample and the research population exhibited right skewness and high peaks, but the sample showed lower degrees of skewness and peak height, with a 0.89-year difference in average birth year.

3.1.3 Age Difference Between Population and Sample Since the sampling frame included only doctoral and master' s students enrolled in Beijing during the second semester, it essentially excluded students who had discontinued their studies or were graduating in 2008. This systematic sampling error likely contributed to the lower skewness and the 0.89-year difference in average birth year. It can be concluded that this discrepancy would not significantly affect mental model construction.

3.2 Factor Analysis

This section conducts factor analysis on user attitudes, behaviors, and cognition separately, extracting factors from each category as a foundation for subsequently measuring relationship strength among attitudes, behaviors, and cognition using path analysis.

3.2.1 Attitude Analysis of Web 2.0 Users First, sampling adequacy test: KMO value = 0.831 (>0.5), suitable for factor analysis; Bartlett' s chi-square = 1240.103, significant. Second, variance contribution rate test: eigenvalues >1 were 3.629 and 1.446, explaining 36.295% and 14.457% of variance respectively. Third, analysis inspection, scree plot examination, and factor analysis before and after rotation are shown in Table 1 .

3.2.2 Behavior Analysis of Web 2.0 Users First, sampling adequacy test: KMO value = 0.758 (>0.5), suitable for factor analysis; Bartlett' s chi-square = 961.866, significant. Second, variance contribution rate test: eigenvalues >1 were 2.988, 1.566, and 1.013, explaining 29.884%, 15.658%, and 10.128% of variance respectively. Finally, analysis inspection, scree plot examination, and factor analysis before and after rotation are shown in Table 2 .

3.2.3 Cognition Analysis of Web 2.0 Users First, sampling adequacy test: KMO value = 0.843 (>0.5), suitable for factor analysis; Bartlett' s chi-square = 1368.939, significant. Second, variance contribution rate test: eigenvalues >1 were 3.831 and 1.371, explaining 38.310% and 13.711% of variance respectively.

Finally, analysis inspection, scree plot examination, and factor analysis before and after rotation are shown in Table 3 .

3.3 Path Analysis

Since this was not a longitudinal study, it was not suitable for constructing causal relationship models. Even when discussing causal relationships, only theoretical explanations and hypotheses could be proposed. This study's SEM only verified correlational relationships. Based on the factors extracted in the previous section, ordinal variable correlation analysis was conducted on attitudes, behaviors, and cognition, with results shown in Table 4 .

3.4 Model Modification

Based on the factor analysis results in Section 3.2, although two, three, and two factors were identified in the three categories respectively, these factors did not meet the requirements of the originally designed research model and could not be theoretically explained. Furthermore, Somers' and Kendall' s coefficients indicated no significant relationship in the "behavior-cognition" relationship shown in Table 4 , and path analysis results were also unsatisfactory. Therefore, model modification or abandonment was necessary. The modification approach involved deleting 12 items related to attitudes, behaviors, and cognition regarding Email, BBS, Chat Room, and Podcast, retaining the remaining 18 items. The three sets of factor analysis elements were then established.

3.5 Model Testing

According to the model modification requirements in Section 3.4, the 18 items for attitudes, behaviors, and cognition were re-subjected to factor analysis, path analysis, and parameter testing, yielding analytical results.

3.5.1 Web 2.0 Attitudes KMO value = 0.762 (>0.5), suitable for factor analysis; Bartlett' s chi-square = 1368.939, df = 15, significant, as shown in Table 5 .

3.5.2 Web 2.0 Behaviors KMO value = 0.709 (>0.5), suitable for factor analysis; Bartlett' s chi-square = 645.754, df = 15, significant, as shown in Table 6 .

3.5.3 Web 2.0 Cognition KMO value = 0.769 (>0.5), suitable for factor analysis; Bartlett' s chi-square = 843.061, df = 15, significant (see Table 7).

3.5.4 Ordinal Variable Correlation Analysis Due to model modification, the dummy variables "attitude-behavior-cognition ordinal variables" were also adjusted, with analysis shown in Table 8 .

3.6 Figure

Based on the model modification in Section 3.4 and model testing in Section 3.5, the revised model is shown in Figure 1 [Figure 1: see original paper]. After modification, the correlation values among attitudes, behaviors, and cognition in the model are closer to significant correlation and more clearly display the relationships among the three constructs.

4 Discussion

4.1 Measurement Variables and Latent Variables

In the introduction, the author mentioned that the research purpose is to conduct interactive design for research-oriented digital libraries and to design user mental models based on the need to describe user behaviors, characteristics, and interaction habits. This study does not verify the classic behaviorist psychology hypothesis of attitude-behavior-cognition but rather borrows this framework to design latent variables for structural equation modeling. The actual measurement variables are the issues closely related to digital libraries mentioned in Section 2.1: individuals' preference levels for network tools, individuals' usage frequency of network tools, and individuals' agreement levels regarding the academic utility of network tools.

4.2 Endogenous Variables and Parameter Estimation

Since it is unknown whether users like Web 2.0, whether they frequently use Web 2.0, whether they hope Web 2.0 will become the development path for next-generation digital libraries, and whether any relationships exist among these three aspects, simultaneous observation and measurement from these perspectives is required, along with correlational research. This involves a relatively complex process: first, results from several measurement variables must have certain associations to be integrated into more abstract latent variables; second, measurement variables must maintain certain differences to ensure research validity, preventing observation of only the same phenomenon while neglecting unobserved matters. This is why factor analysis and path analysis were employed in Sections 3.2 and 3.3.

4.3 Non-Direct Relationships and Path Diagram

Originally, 10 network tools were measured, but the model was later modified to 6 network tools, with each tool assessed through three different methods regarding attitudes, behaviors, and cognition. This is because the original 10 tools, after factor analysis, could not adequately measure the operational variables they represented, and the resulting dummy variables (latent variables) also failed to show good correlations. For example, attitudes reflected by Tag, RSS, SNS, and Chat Room (Table 1) could not explain users' usage of IM, BBS, and Chat Room (Table 2). Therefore, Section 3.4's model modification proposed the

principle of simplifying observed variables and extracting only one factor, which is a simplified model. Although Section 3.5' s model validation still could not demonstrate strong correlations, the coefficient values were closer to significant correlation and could be theoretically interpreted.

4.4 Model Identification

Among multiple model comparisons, Sections 3.2 and 3.3 represent the first model (the prototype), while Sections 3.5 and 3.6 represent the final model (the identified model). It must be emphasized that deriving a set of latent variables from a group of observed variables to form a model with internal mechanisms inherently allows for multiple possible models. Researchers conduct model identification and select the optimal model that simultaneously meets three criteria: research purpose, theoretical foundation, and data validation (see Figure 1).

5 Conclusion

5.1 Practical Significance

The study more clearly demonstrates network users' attitudes toward, usage of, and cognition regarding Web 2.0-style services in the new environment, as well as the correlations and integrity of the integrated model. For digital library interactive design, understanding based on mental models will advance the underlying theory for creating and utilizing personas that reflect user behaviors and characteristics, providing a more reasonable inferential foundation. This enables senior managers, frontline librarians, and programmers who code web library applications to understand user characteristics and behaviors, forming consistent discussion objects. As an empirical survey result, the mental model can provide background knowledge for deeper user understanding in the short term. When combined with other related research in the long term, it will gradually and accurately capture users' personal goals and ideas.

5.2 Research Limitations

Similar studies require more effort to understand users more precisely. Mental models themselves need repeated validation through both pure academic and applied practice.

5.2.1 Temporal Variability Tracking changes in the network environment and continuously exploring user behavior makes model modification or redesign highly likely.

5.2.2 Methodological Limitations Questionnaire surveys are suitable either for validating theories or for collecting data to explore research objects. Conclusions from questionnaire research are not suitable for in-depth explanation.

5.2.3 Subject Limitations Since the research subjects were graduate students from the Chinese Academy of Sciences, the research conclusions are not suitable for explaining phenomena or mental models of students from other universities or the general public.

5.2.4 Research Defects Only one factor was extracted, making the single explained variance directly become the cumulative explained variance. Although the values were close, they did not reach above 50%, which is an unsatisfactory factor analysis result with weak explanatory power. In a strict sense, this belongs to model hypothesis formulation rather than model validation.

5.3 Future Research

Despite research limitations, more studies can be conducted based on this research, such as: reviewing and improving mental models, combining interview methods to establish personas, longitudinally tracking the same user group, integrating other related research, and employing other research methods.

6 Conclusion

Regarding digital library services and system functions in the Web 2.0 environment, librarians mostly view what Web 2.0 can offer libraries from their own perspective. There have been many discussions and suggestions in this regard. However, from the user perspective: what are users accustomed to doing in the Web 2.0 environment? Which Web 2.0 tools do users prefer? What expectations might they have for digital libraries? Such discussions are relatively rare in library and information science literature. Moreover, there is a lack of theoretical and practical experience support.

Although the model proposed by the author has obvious practical significance, it currently still lacks sufficient theoretical basis and application foundation. Therefore, more related research work is needed to further confirm the reliability and applicability of the theory. However, the most important thing is never to give up exploring user behavior and caring about users.

References

[1] Robert Hoekman Jr. Designing the Obvious: A Common Sense Approach to Web Application Design. Translated by He Xiao. Beijing: China Machine Press, 2007.
[2] Alan Cooper. The Inmates Are Running the Asylum: Why High Tech Products Drive Us Crazy and How to Restore the Sanity (2nd Edition). Translated by Ding Quangang. Beijing: Publishing House of Electronics Industry, 2007.
[3] Jesse James Garrett. The Elements of User Experience. Translated by Fan Xiaoyan. Beijing: China Machine Press, 2007.
[4] Veldhuyzen W S, H.G. The internal model concept: Application to modeling

human control of large ships. Human Factors, 1977, 19: 367-380.
[5] Wickens CD. Processing resources in attention // Varieties of Attention. London: Academic Press, 1984: 63-102.
[6] David H. Jonassen. Operationalizing mental models: Strategies for assessing mental models to support meaningful learning and design supportive learning environments. [2008-07-12]. http://education.uncc.edu/jagretes/instructional%20design%20articles%20&%20cor
[7] Liu Wenge, Liu Tingting. Analysis of institutional change theory represented by North. Academic Exchange, 2007(3): 63-67.
[8] Simon. Selected Works of Simon—Academic Fine Selections of Nobel Economics Prize Winners. Translated by Huang Tao. Beijing: Capital University of Economics and Business Press, 2002.
[9] Masahiko Aoki. Comparative Institutional Analysis. Translated by Zhou Li' an. Shanghai: Shanghai Far East Publishers, 2001.
[10] Qiu Haozheng. Structural Equation Modeling—Theory, Technique, and Application. Taipei: Shuangye Bookstore, 2006.
[11] Gu Liping. Web 2.0 User Behavior Survey Research—Taking Chinese Academy of Sciences Students' Use of Social Software as an Example. Library and Information Service, 2007, 51(9): 102-103.

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Note: Figure translations are in progress. See original paper for figures.